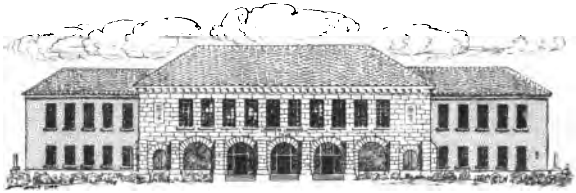
STORIES OF INDUSTRY

CHASE AND E. CLOW

VOL. I.



STORIES

OF

INDUSTRY.

VOLUME I.

BY A. CHASE AND E. CLOW.

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PREFACE.

Southey tells us that "it is with words as with sunbeams, the more they are condensed the deeper they burn."

Having this thought in mind, therefore, we have endeavored to give, in as few words as possible, a little interesting information for young people; something that will aid them in acquiring habits of *observation* and lead to a knowledge of the *common things* connected with the arts on which depends the well-being of our race.

Truly "that is a good book which is opened with expectation and closed with profit;" if this may be said, even in a small degree, of this little volume, the authors will feel more than compensated for the labor and thought expended in its preparation.

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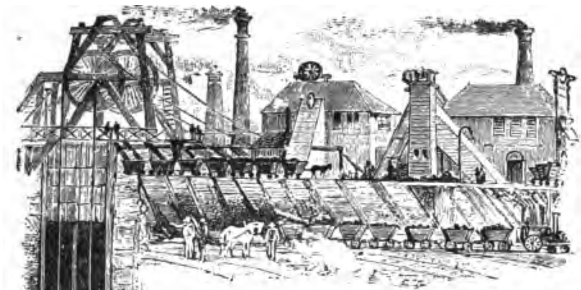
ANCIENT MODES OF LIGHTING.



STORIES OF INDUSTRY.

COAL.

DID you ever stop to think when you have watched some railway engine puff out of its round-house home, or whiz away over the country with its precious freight; or when you have visited some noisy mill or foundry, what a vast amount of coal it must take to turn so much machinery?

Coal is to our manufactories what the main-spring is to the watch, and hardly any labor can be performed without it. Yet, before we can have so much as a hod of coal, mines have to be mapped out by skillful men; tunnels made or deep shafts sunk; gear fixed to bring the coal up; means tried to drain and air the pits; miners paid for their hard toil and risk of life, and trucks and wagons made to carry the coal. Then there must be roads made to reach the sea-ports; ships to carry the coal over the water, and railways to take it from place to place over the land.

Every step of this work is costly. The sinking of a shaft or pit is very expensive labor, and some pits have been bored very deep without coming to coal. Often after it has been carried hundreds of miles the coal has to be taken out of the coal ships (colliers), put into barges or lighters to go up the rivers; or, perhaps, is transported to some railway again. Last of all comes the business of the coal markets, the merchants and small dealers, who bring the coal to our cellars.

Have you noticed that some coal burns with a great deal of flame and smoke? That is because it is rich in

mineral pitch or bitumen; it is called bituminous coal. That hard, stony, clean-looking coal which burns with such a feeble flame, yet gives out such intense heat when once it is lighted, is the anthracite coal.

Until close stoves and the hot blast for furnaces came into use, anthracite was but little used for fuel, as it does not light easily and requires a strong draught to keep it burning.

The countless uses of coal! how they show the power man has to turn the knowledge and skill he acquires by study, hard work and *observation* to good account. This one product of the earth, by means of man's intelligence, has made a complete change in the industries of our country.

It is only a few hundred years since the motive power of steam was called forth by coal. Now nearly every country is scored with steam railways; and our mills and factories are crowded with steam engines and looms.

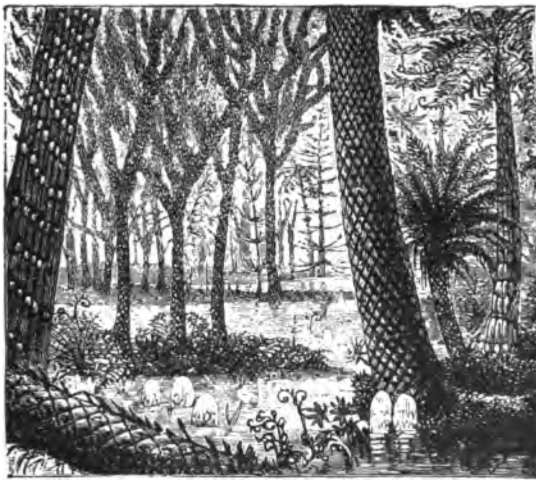
Before coal was used to produce steam the sites for busy towns were selected near some mill stream, and the woods were seats for smelting iron. Now iron-making has gone to the coal fields, where the coal, the iron ore, and the lime-stone, or flux, which helps to melt the iron, are all found close together.

Some people ask, "If we go on using such an immense

amount of coal every year will not the supply give out; and then what shall we do?" But think of the coal area of our land! there is the Allegheny coal-field, bordering the Alleghenies on the west side and reaching from the north line of Pennsylvania to the middle of Alabama, 58,737 square miles; the Illinois coal-field, which covers a large part of Illinois and portions of Indiana and Kentucky, its area 64,887 square miles; the Missouri coal-field, lying west of the Mississippi in the States of Iowa, Kansas, Arkansas, Missouri, and Texas, supposed to extend over 47,138 square miles. When we add to all this the anthracite basins of Pennsylvania and Rhode Island, and the coal-fields of Virginia, Michigan, and North Carolina, we think there is little danger that these trouble-borrowers or their grand-children will see the coal supply exhausted. England, France, Prussia, Belgium, and Australia are also rich in coal.

As the coal in the mines is by degrees used up, men have to dig lower down to deeper beds, and this adds to the labor and danger in working. The cost of coal, the need we have for it, and the hard toil it takes to "win" it, and the risk to the miners' lives, all preach a sermon to us to be careful in its use.

Scientific men have been thinking out other means of getting the fuel we need, until we have mineral oils and gas so good and cheap that we can use them for cooking or to warm our rooms.



PRIMEVAL VEGETATION.

WHAT IS COAL?

WHAT is coal? How came we to know that if we bored pits a quarter of a mile deep, and sometimes deeper, into the earth, we should find a black stone that would burn and be so useful for fuel? Coal is found in seams or beds. In some coal-fields, as many as eighty of these beds have been counted, and in some other places double this number. Some of the seams are as thin as a leaf, and they range through every thickness to nearly thirty feet. The beds are not dug

out for fuel unless they reach a thickness of two or three feet at least, as they would not pay for working. The seams or beds are called measures, and if they had lain flat in the crust of the earth, it is pretty certain that we should never have known much about them. But the coal measures are not flat; they slope or dip, and stretch upward as well as downward, and the edge of the coal bed, here and there, crops out on the surface. This surface coal is not as good as the deep-seated coal, but it was the first used, and it shows the direction of the slope or dip.

When once this slope was found, it was easier to sink a shaft down to the coal, the depth of which was reckoned beforehand, than to keep digging the coal deeper and deeper from the spot where it cropped out.

In Belgium the coal measures are tilted nearly upright, and, therefore, must be dug from the surface downward, deeper and deeper. There is a mine in Middle Island, New Zealand, fifty feet thick and 3000 feet above the sea level. Here the fuel is tunneled out, no shafts are sunk, and there are no explosions of fire-damp, the filled trucks going down the slope of the mountain pull up at the same time a train of empty ones to be filled.

Everywhere between the beds of coal are strata or layers of other rocks, such as sandstones, shales and clays, which seem to have been left many, many years

ago as sediment in the bottom of water. The roof of the coal or rock, just above the coal-bed, as well as the floor, is, as a rule, a shale of hardened mud. These shales, which split very easily, have stamped upon them impressions of leaves and ferns, and even the fossil stems and roots of plants —*often the relics of lofty trees!* If we magnify a thin scale or section of coal, a plant-like structure can be seen. There is a kind of coal, called lignite, or brown coal, which seems to be the link between true coal and living plants. Now and then a trunk of a tree is dug out; one end of which is scarcely changed from wood to mineral matter; *the middle* of this is brown coal, *the other end true coal!* Fossil plants in the coal measures vary in kind according to the place of the beds. Those farthest north, such as are in the Greenland coal, are like the plants which grow in Middle Europe.

Marks of ferns are more common than any other plant in the coal measures. The beautiful fronds or leaves which, as there are no flowers, bear on their surface the fruit or spores of new plants, are very plentiful. This is not because they were the only plants which grew in those ages long gone by, but because they were so resinous as to be the last to decay. Besides ferns, we can trace in the texture of coal the grain of pine and fir wood, or the cone-bearing trees; and in the fossil stems, plants like the common

moss. Our present ferns and club mosses are pigmies compared with those that lived so long ago, and reached the size of giant trees. Similar lofty tree-ferns now grow fifty or sixty feet high, in the islands of the South Pacific Ocean.


PLANTS FOUND IN THE COAL

From these facts we infer that the coal-beds are a changed state of former vegetation, and that the bitumen of the coal is the altered resin and turpentine, so plentiful in trees of the fir and pitch-pine family. To account for the great depth and the number of the coal-beds, we may be certain, that every seam was, however far back, a field of vegetation on the surface of the earth, and that every layer of shale or clay, now the floor and roof of the coal-beds, was formed by mud settling down at the bottom of water. So we see that the land has been covered by water as many times,

at least, as there are strata or layers of shale; and has become dry again as many times as there are beds of coal. We believe, too, because the plants were tropical and of great size, that the coal countries must have been, at times, much hotter than now.

Fossil remains of animals such as can live only in hot climates, and others which can live in cold climates, are found in abundance in the rocks. The nature of the rocks thus proves that, at long intervals the land has had to bear the extremes of heat or cold, for ages together.

When we walk in some of our woods we sink up to our knees in the fallen leaves. As these leaves decay, they form a vegetable soil. Every autumn brings down the leaves and adds a new layer to its depth, so that by the time a hundred years have passed by, this soil has become very deep, and in it are buried whole forests of ancient trees! How much higher the trees now growing must be rooted than those which first grew upon the earth!

In Europe there are many peat meadows or bogs. These bogs are masses of vegetation formed of the matted roots of decayed grasses and mosses which die down every year, and of the fresh annual growths that take their place. In the deep Irish bogs are found half fossil trees, called bog oaks, out of which fancy articles are often carved.

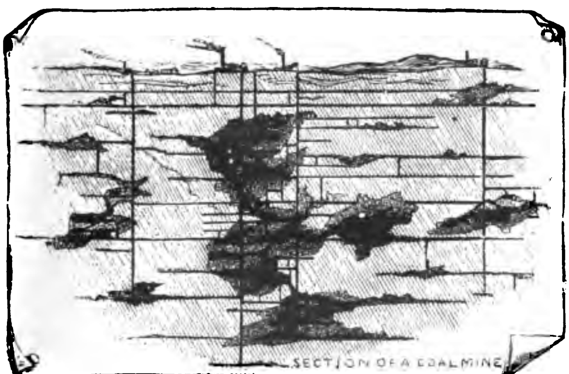
The deep parts of the bogs are dense and dark, from the pressure of the soil above, and seem like lignite or coal. *Roman pavements have been found ten feet below the surface of some of the European bogs.*

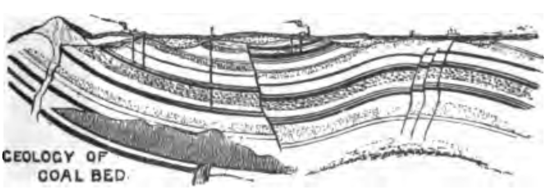
Now let us look forward, say twenty thousand years. By that time the land will have sunk and been heaved up again many times; many changes of layers of sediment and new growths of bogs will have occurred. Then, that which is marshy land stretching out in the sunshine will have sunken deep down into the earth; will have been pressed into a dense substance by the heavy earth above it, and have become only as many inches thick as at first it was yards. Heat and chemical forces, acting upon this through so many ages, will have changed it into the black, shiny mineral which we call coal.

So you see the kind of coal in a bed depends upon the kind of plants or trees that grew upon it when it was at the surface of the earth; upon the amount of pressure above it; and upon heat and time. The giant trees whose roots and stems are in the coal measures show us that the vegetation of the earth, long before man came to live upon it, was in structure something like a moss which now seldom grows more than a foot high.

Our coal-beds tell us a great deal about the ancient world and the appearance it must have worn, so long

ago that we cannot count the years. We learn from them that part of our country has for many ages past been, at times, as hot as the Tropics, then as cold as the Poles; that it has sometimes sunk below the sea and at other times been raised up high and dry. Learned astronomers have found out and taught us how such changes have been brought about by the movements of the earth with regard to the sun. By-and-by it will be part of our lessons to study and understand these wonders.





A mine of coal is dug out on a very regular plan. When a shaft or pit is sunk down to the bed, the

miners do not try at once to get all the coal within their reach, but they cut or drive tunnels, which they call drifts, and as soon as they get a little way in, they cut cross drifts right and left, so that at last the mine consists of narrow lanes or passages, and huge square blocks or pillars of coal, as regular as the squares on a chess-board, are left to support the roof. As soon as the drifts reach the bounds of the mine, the miners remove these pillars, the most distant ones first, and let the mine fall in; and this is the most dangerous part of their work.

When the mines fall in, it often causes the surface of the earth to sink. In the coal districts it is not uncommon for great cracks to appear in the house-walls, for chimneys to lean over, and buildings to fall, from the giving way of the foundations.

Both in driving a passage through the seam and in hewing the coal, the labor is much lessened by the readiness with which the coal splits in certain directions. These directions are three in number, and are called planes of cleavage.

The first are the planes of the bedding, running even with the roof and floor of the mine. The second and third planes are at right angles to the bedding, they run from roof to floor. This natural cleavage renders it simple to hew the coal in brick-shape blocks, the long sides of which are known as the face, and the

short sides, whose fracture is the least regular, are called the ends. The sides cleave bright and smooth, but the planes of bedding are dull and sooty, because of a black and fibrous powder, to which the name of mineral charcoal and sometimes of mother-of-coal, has been given, and which lies between the planes of cleavage. Mixed with this loose substance may plainly be seen the remains of the stems and leaves of plants. Mother-of-coal soils everything it touches, and renders the miners at work, and even visitors at the workings, in a very short time as black as soot. It also ignites, instantly, in presence of a light, and some dreadful explosions in the pits, the cause of which could not be clearly traced, have been thought to be due to the firing of coal-dust.

COAL.

For thou shalt forge vast railways and shall beat
  The hissing rivers into steam, and drive
Huge masses from the mines, on iron feet,
  Walking their steady way as if alive,
Northward, till everlasting ice besets thee.
  * * * * * * * * *
Thou shalt make mighty engines swim the sea,
Like its own monsters — * * * *
Then we will laugh at winter when we hear,
The grim old churl about our dwelling rave:
Thou * * * *
Shalt * *
* pull him from his sledge, and drag him in
And melt the icicles from off his chin.

- BRYANT.

DAVY LAMP CLANNY LAMP

THE FLOOR RISING.

A PIT VILLAGE

VISIT TO A COAL MINE.

LIKE Columbus in America, visitors to the coal mines land themselves in a new world. The aspect of the district is quite strange. Everything is black. Coal in huge black mounds is everywhere. Grim, skeleton arms and wheels, the tackle of the different pits, stretch out in the murky skies, hoisting and lowering the cages of coal, while dense black smoke from

the furnace shafts and coking ovens obscure the sun and fill the air with flakes of soot. The scanty herbage which wrestles with fate, and the few sheep which crop it, are black. The railroad trucks and roads are black. Black barges laden with coal are towed along black paths through ink-black canals.

Let us now wend our way to a large mine near, directed by lurid streams of natural gas, which are ever flaring, night and day, fed from the exhaustless stores of "bottled sunshine," as George Stephenson said, which the ancient ages placed to man's account in the deep crust of the earth. Careful scrutiny of our Davy lamps, to see them lighted and locked, goes on while the gear of the pit moves; the stout wire band or rope starts on its downward course, swift as a dart, and its twin brother mounts upwards as fast, the one freighted with a cage of miners bound for the bottom, the other with a cage of coal for the top. We look over into the dark depth. Who ever could have first thought of digging such a hole as this to see what he could find? We cannot stop to think. Our foot is on the plank, and we go "down-stairs," dangling at the end of a quarter of a mile of rope.

The movement is so swift and easy that we seem to be standing still, while the walls of the pit rush upwards. It is said that one can see the stars in the daytime when looking up from a deep well. We look

up to prove this fact, and are greeted with drops of black water from the sides, which give to our eyes for a time the sight of many stars. Just as we fancy that the bottom of the pit is about to bump against our cage, the pace slackens, lights appear, and unearthly

voices and uncouth beings welcome us below and hand us out. We have been shot into one of nature's vast coal cellars, stored countless ages ago with fuel, in quantities large enough to last for ages to come.

The temperature is warm, as is also a stream of black water running through the mine. The heat

increases as we descend into the earth's crust and helps us to understand better how the coal can be changed from vegetable to mineral matter. Collecting our wits, we have to leap aside to let the ponies approach with their trollies of coal. Yes, ponies are here, some fifty or more, who never see daylight, and only know of night by their hours of rest in their stables at hand. They emerge from the gloom of tramways laid in the tunnels and from various quarters, their tramp and the creak of wheels giving notice of their approach. With no time to lose they are unyoked and yoked again to empty trucks and go back into the darkness.

Our first duty must be paid to the furnace, the "tutelary genius" of this mine. We leave gas jets behind and trust to the feeble glimmer of our lamps as we wander into the recesses of the pit. Now we must bend nearly double at the risk of a crick in the back, for the roof is very low.

The road is dry and dusty. Right and left, drifts, at intervals, lead to the workings; and the coal, still in place as it "grows," glistens in the walls. The roof is kept from falling by close massive timbers or walls of rock. The danger, strange to say, is often, not from the roof falling, but from the roadway rising. So vast is the pressure of the overlying strata that the roadway, relieved by excavation,

heaves up, and with such force, as to fracture the metal-rails; to snap in two the thick short trunk of a tree, put as a support, and soon to fill up the drift. The timber in a mine appears sufficient, if left there long enough, to make another bed of coal. Our passage is blocked by a trap door, our guide asks us to wait, for the noise of wheels the other side announces an arrival. The door opens, and a truck of coal passes out, and we pass in. A rushing sound, as of floods of water, besets our path. Our friendly guide tells us it is the air to ventilate the mine. He opens the door that divides the passage, and we pass under, and the roar of mighty water ceases. We feel, however, a stronger current of air setting in our own direction of traveling. We are, in fact, close to the furnace, the sole means trusted to for the ventilation of this mine. The downcast current of air from the shaft we descended, moves along one side of the partition through every drift and working of the mine, driving the foul air and gases before it, and returns on the other side, driving along faster and louder as it nears the all-consuming furnace, which it feeds with the roar of the hot blast.

And what a chimney shaft, over four times as high as Bunker Hill! "Shall we go up it?" Surely our guide is poking fun at us. No; he says he generally goes upstairs that way because it is warmer. It is the

upcast shaft, with cages ascending and descending the same as with the downcast. We straighten our aching backs in presence of the Fire King, bending low again in leaving; — we cannot well do otherwise in a three-foot seam.

Here are pitmen and boys in free and easy costumes, limited as a rule to black and ragged trousers. Here a stalwart miner lies sideways at full length with his pick, under-cutting the coal, so that the upper mass comes down with a run. There another, bent upon earning as much money as he can, has worked a dangerous distance without placing props.

A group yonder, indulging in a few moments' rest, have put their lamps on the points of their picks, against orders, and long to smoke, but dare not. The officer gives a friendly word of warning, saying to some reckless one, "You never know when an accident may happen." The mine is treacherous and fiery. Explosions have cost the lives of hundreds of miners.

Remembrance of these gives a gentle sadness of tone to the man's voice, for he himself lost two fine boys in the last catastrophe. He takes us to the scene of death, now shut in from the rest of the mine. He points out where the poor charred bodies were found. The seams of coal crumble to the touch, the surface being burned by the fire.

By screwing down the flame in our lamp it will lengthen into a needle point if there is gas in the air. We try it, but no gas can be found to-day.

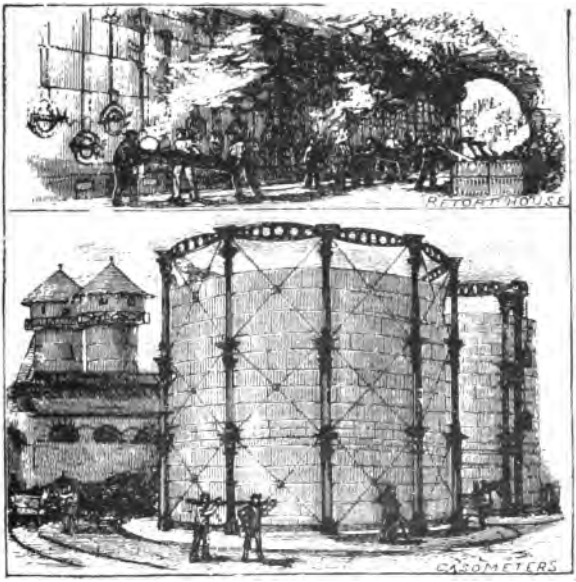
We ascend by the warm upcast shaft with the same curious feeling that it is the pit which moves. As the pit sinks faster and faster, it leaves us at last on top, where the wintry mists seem bright after the murky darkness of hours in the coal-pit.

The first coal discovered in America was by Father Hennepin, the Mississippi explorer, near what is now Ottawa, in Illinois. In the year 1813 the first mining was begun, when five boat-loads of coal were floated down the Lehigh river, and sold for $21 per ton in Philadelphia. At that period wood was almost the entire fuel, Liverpool coal being considered a rare luxury.

The first regular shipments of coal from the Pennsylvania mines began in 1820, and the industry has now reached enormous proportions, the product being valued at over $59,000,000 annually.

In 1881 there were mined in Pennsylvania about 21,000,000 tons of bituminous coal, as well as over 28,000,000 tons of anthracite.

The States of Ohio and Illinois produce the next most extensive yield of bituminous coal, each giving about 5,000,000 tons annually.



SOMETHING ABOUT GAS.

HOW many have seen, while watching the fire on a winter's night, the jets of curling smoke bursting from a lighted coal, and every now and then blazing up with a pleasant, rushing sound. He must have been an intelligent man who first thought of catching these jets of smoke, before they lighted, and carrying them through pipes any distance, to light at the

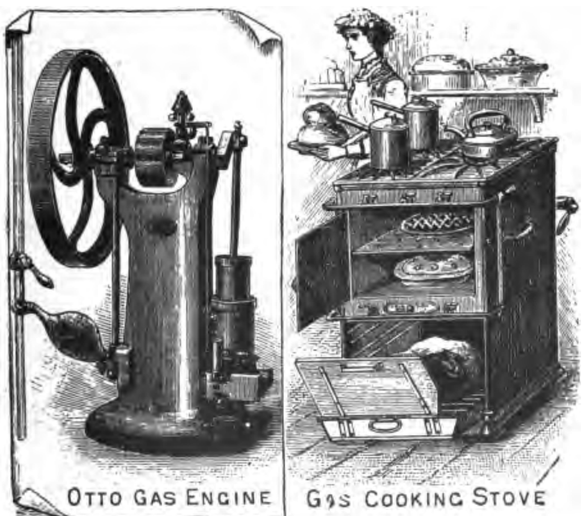
other end. Yet this simple idea led to illuminating our cities with gas. Man did not invent gas, but the mode of turning it to our comfort and welfare.

It is told of the great Dr. Johnson that, when he was looking out of his window one evening, he saw a lamp-lighter go up a ladder to relight an oil-lamp that had just gone out; he noticed that the wick caught in a moment from the vapor which still rose from it. "Ah!" said the Doctor, in a prophetic vein, "one of these days London will be lighted by smoke." In some coal-fields the gas escapes, and makes its way to the surface, where it breaks through in a never-dying stream of fire. Such natural gas is now brought up to the surface through tubes, and often used instead of coal or artificial gas.

Before coal-gas was used, our towns and streets were lighted with dull oil-lamps, hanging from cords or chains slung across from side to side, and our villages trusted solely to the moon, as the people still do in many towns.

Man's intelligence, however, is never at rest. Gas no longer satisfies him as an illuminator; it seems likely to find its chief use in the future, as a means of warmth, to burn in our fireplaces, to the saving of the cost and dirt of coals, and for cooking purposes. With asbestos fuel, which burns brightly and throws out heat, without smoke, soot, dust, cinders or ashes, a gas

stove satisfies the love of a cheerful open fire, kindled in a moment by turning on a jet, and put out as quickly, yet never consumed. Intelligence has adapted to our use the electric light, whose brightness, like that of the sun, illumines the whole atmosphere with the light of



OTTO GAS ENGINE   GAS COOKING STOVE

day, and gives a splendor to the night such as the world has never before seen. Just as the light of the stars, which are shining in the day-time even though we do not see them, are put out by the bright sun, so the electric light puts out the gas lamps; and the genius of inventors, which was taxed to make gas brilliant,

is now directed to reduce the intensity of the electric light.

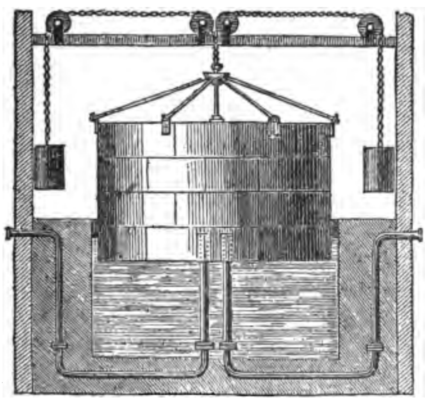
The principle of gas lighting is easy to test. If you fil the bowl of a clay pipe with coal dust, and plug it with clay, and then put the bowl in the fire the

A CITY BY NIGHT.

heat will drive out the gas through the tube or stem, when it can be lit as it escapes. On a large scale this is what is done at the gas-works. Coal is put into iron tubes, called retorts, the gas is driven off by heat, but in an impure state, being mixed with the

vapors of ammonia, tar,and sulphur. It has to be put through a process to rid it of impure matters which would dim its light. The dull gas first made was hardly to be compared with the clear, colorless flame which illumines our houses now.

Until the gas is wanted, it is stored in the gas-holder; this holder is in two parts, the tank, and the holder proper. The tank is a pit in the shape of a



The Gasometer.

cylinder which is kept filled with water to prevent leakage of the gas. The holder is above the tank, and is filled with gas. Great care has to be taken to prevent explosions. These do sometimes happen despite caution, shaking the district for miles around and often destroying life.

The wonderful powers of coal do not end at gas.

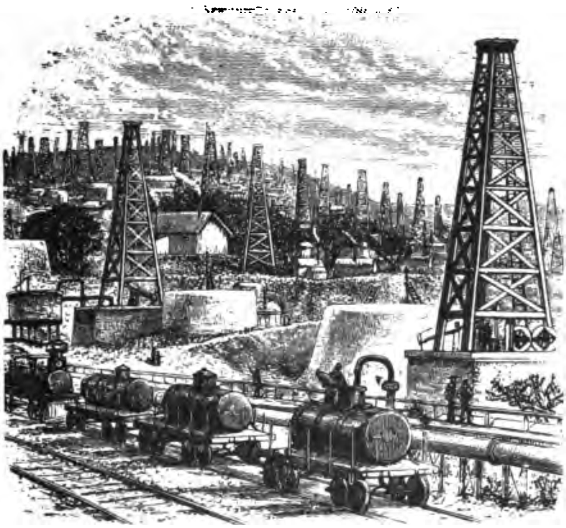
After the coal has been heated and the gas removed,

there is left a black, porous, hard, but brittle matter. This is called *coke.* The gas companies sell it for fuel. It makes a quick, hot fire.

Other things produced by the manufacture of gas are hartshorn, ammonia, the strong-smelling *coal-tar*, from which chemists make a great many beautiful colors known as *aniline dyes*, and — would you believe it?— the snow-white, waxy substance called paraffine, which you have seen in the shape of candles. *Even the jet ornaments you admire are made from one kind of coal.*

Fuel for cooking, for warmth and for gas; fuel for smelting and forging metals; fuel for the arts of life which depend upon boiling water, or upon dry heat; fuel for the engines that drive our machines, mills and railway trains; fuel for other useful ends, too many to name, makes greater demands upon our coal-beds every year.

It is due to coal that we have steam-engines to begin with, and that we can work them; that we can travel in a few hours by train, as far as we could travel in a week, not many years ago; and take a voyage round the world in as few months as it once took years. *Everybody gains by the saving of time,* for no one thinks of saving time for the sake of wasting it, but to try to produce more of the comforts and necessaries of life.



PETROLEUM SPRING.

PETROLEUM.

WHEN the wild Indians alone livèd in our country the only way of getting a light and kindling a fire was by rubbing two pieces of wood together. Our forefathers lit their rude homes with sputtering tallow candles. Those of us who cannot have gas or electric lights can make our homes light and cheerful with kerosene oil or petroleum.

This oil had been found in many parts of the United States for many years, but it was not until August of 1859 that it was found in large quantities. At this time a boring was made at Oil Creek, Pennsylvania, and *one thousand gallons a day were drawn from it for many weeks*. The news of the discovery spread rapidly; thousands of persons flocked to the neighborhood in hopes of making a fortune by "striking oil."

Our wants of to-day are supplied from the northwestern part of Pennsylvania, but there are rich oilfields in Michigan, Ohio, West Virginia, Kentucky, Tennessee, Texas, and California.

When a spot has been decided on — "located" as the prospector calls it — as a likely place to find petroleum, a wooden framework, looking something like the staging put up in building a church steeple, is built over it. This is called a *derrick*, and these derricks are characteristic features of an American "oil-field." In this, or more commonly a little distance away from it, is an engine which works the drilling tools in the derrick. The hole which is drilled may be anywhere from a few hundred to two thousand or more feet deep before oil is "struck." It is usually only about eight inches wide at the top, narrowing to about two inches at the bottom.

Sometimes the oil does not rise to the top of the well when, of course, it has to be pumped up. At other times

it runs out at the top and so forms a "flowing well." A flowing well is naturally more valuable than a "pumping well." Various ingenious contrivances are used to get the sand and broken rock out of the bore-hole; and sometimes a well has been started by exploding a dynamite cartridge at the bottom of the hole. After all the apparatus is at hand, two or three men do all the work of making a well.

From the wells the petroleum is conveyed to storage tanks and, in the Pennsylvania region, from them through long lines of pipe (just as water is carried) to places where it is wanted. These "pipe-lines" are managed by large companies who pay the owners of the wells for the oil they take. The pipe-lines end either at places where the oil is loaded on the railroads in tank-cars — long iron cylinders — as at Tamanend and Williamsport, in Pennsylvania; or at the refineries. One of the largest pipe-lines runs for 300 miles from Olean in Western New York to New York City.

Kerosene is made from petroleum by a process of purifying or refining, in the great refineries situated near the large cities of the Atlantic coast. Other products are also obtained in this process — such as *naptha*, *benzine*, *gasoline*, some of which are used, from their property of dissolving other things, — for cleaning goods and for making paints and varnishes, as

well as for giving light and heat; though for the two latter purposes not so safe as kerosene. Some of the heavier oils obtained in this refining are used in machinery to lessen the friction (lubricating). From the ill-smelling petroleum is also made the now common jelly-like ointment, *vaseline*. And who were the people who discovered so many uses for all these things? They were simply people, who as school boys and as men, were *thoughtful* and "*kept their eyes open.*"

METALS.

THE best known metals are gold, silver, iron, lead, copper, zinc, and tin. Sir Humphrey Davy, the great chemist, proved that all the common earths and alkalies have metals for their base, and can be reduced from the matrix, or earthy substance in which they are imbedded. These metals are elements or simple bodies. Some of them we have learned to extract cheaply, and they are much used in the arts. Others remain rare and costly, awaiting our further knowledge before entering into man's service.

When alloyed with copper, or tin, aluminium produces a bronze, better than any other mixed metal in use, for ship fittings, sheathing, steam propellers, and for the manufacture of artillery.

Gold and silver are called precious metals, because they do not corrode or waste in melting, and on account of their great scarcity and value. Another metal, platinum, is like the precious metals in these respects. The more common metals, but iron in particular, are often distinguished as the useful metals.

Metals are spread over the whole earth; iron being the oftenest met with, and gold the next. Gold is found native or pure, though sometimes mixed with silver, copper, or mercury. The common metals are so blended with earths, that they have to undergo a series of transformations before they are obtained in their pure state, ready for man's service and wants. Much knowledge, which it took many ages to gain, is required in the successive operations of reducing the ore to the state of pure metal. Iron, in particular, is very stubborn and difficult to treat. Its ores lay unapplied during the whole history of the most ancient nations.

Metals form a very large part of the earth's mass. It has been reckoned that one-third by weight consists of metallic ores, while five per cent. of the lower rocks and a higher rate of the upper rocks, are iron. The

water of the ocean also holds most or all of the metals in solution.

Water, in fact, is the grand agent which has played its part in the deposit of metals, whether in vast beds of ironstone, or veins of other metals which fill the crevices of rocks — whether in small quantities widely diffused, or in abundance in spots as widely apart.

Water makes its way through the earth to its greatest depths, and is the cause of the ceaseless changes which the rocks undergo. Water filters or strains through the surface soil, or operates in currents beneath, under enormous pressure. No rock, not even the hardest crystal, is free from water, which appears to make its passage the more easily the greater the depth. It is met with in the deepest mines, and the hewer of stone is as familiar with the "quarry water" as with the stone he works. An ocean of water, equal to the ocean which fills the great hollows of the earth's surface, or that other ocean of vapor which fills the air, is absorbed by the crust of the earth as by a sponge. Water is the universal solvent. Give it time, heat and pressure, and no element can withstand its influence.

A principle rules in nature whereby atoms, or particles of a like kind, attract each other. Atoms of metals, held in solution by water, may travel many miles, before meeting with the proper conditions to unite with their kind.

GOLD.

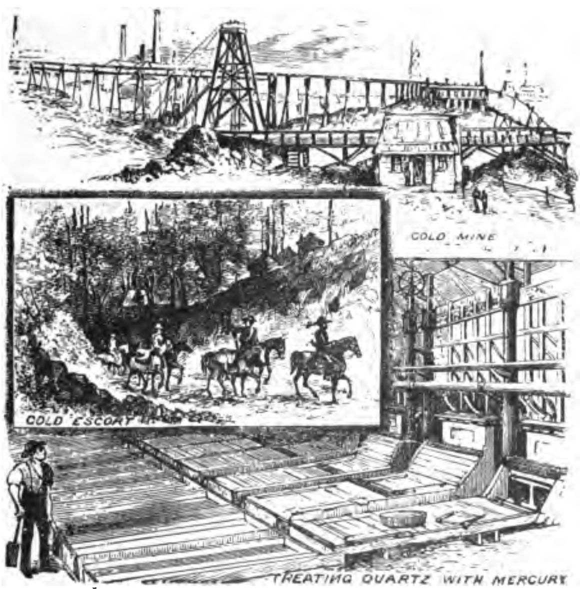
THIS precious metal is mined in every quarter of the globe. It is found in most of the countries of Europe, most of all in Russia. Various regions of Asia and the East Indian Islands furnish further supplies, and large quantities come from North, South and Central America. But California and Australia have, in the immensity of their gold productions, overshadowed that of the rest of the world, either in ancient or

modern days. Gold is discovered in the sand and mud of rivers; it has been, by the action of the water, brought down from its home where it formed in the mountains. Often it is found in veins or lodes in quartz rocks, with iron pyrites. Gold is never found in the oldest rocks like tin and copper.

It takes the form either of grains or nuggets or solid masses of metal. In any case it is mixed with or encrusted with earth and alloy. The earthy part can be removed by water. In old times in California this used to be done in pans or in what the miners called a "cradle" — a box on rockers and open at one end. But this slow process is now done away with; hydraulic engines and sluices taking the place of the first rude implements. If the gold is embedded in quartz the rock must be crushed to powder before washing. This crushing is done in different ways in different countries, but most of the quartz of California is reduced by a machine called the stamp mill. When at last the heavy metal is crushed and washed free from earth it is further purified by being treated with mercury or quicksilver: this mercury is afterward driven off by heat, leaving a mass of spongy gold behind which is afterward run into ingots or bars.

Gold plays an important part in history. There must have been lavish stores in the days of the early

oriental empires, whose extravagancies both profane and sacred histories picture. Still more must have been in Rome. Lucullus could give a banquet to Cæsar and Pompey and *spend a whole fortune upon it.*



In olden times there was great abundance of the precious metal in Asia, and many legends and tales about it.

We read of the golden fleece and the Argonauts; of the gold of Ophir; of the golden sands of Pactolus, and the fable of the rich King Midas. There are

traces of ancient workings and of large stores of gold in Egypt; and gold work was put in the tombs of the Pharaohs. Beautiful ornaments of gold were also stored in the tombs of the Etruscans. Troy had abundance of very pure and easily-worked gold.

Arabia was the El Dorado of ancient days *with twenty-two gold mines.* Africa was rich in metal. Quartz veins are met with in the interior which lead us to believe that gold-mining may again become an active industry in the Dark Continent.

In January, 1848, gold was discovered in California. The news spread over both hemispheres. Excited multitudes poured in from Mexico, the South American coast, the Atlantic States, and even from the Sandwich Islands. San Francisco, a station of a few inhabitants, sprang in a few years to a splendid city of 50,000 people. Its harbor was filled with the fleets of all nations, and the State of California counted three millions of souls. A mania for gold seized young and old, to the neglect of all other industries. Food, clothing and the common necessaries of life rose to fabulous prices. Gold so fixed men's thoughts, that the rich mines of silver and cinnabar (ore of quicksilver), of plumbago or blacklead, of manganese, copper, iron,and coal were thought nothing of, and passed over. After a few years, the gold fever yielded to healthier industries, and the resources of California

began to be wrought. Tillage of the soil was resumed, and the finest grains and fruits were raised. Farming now flourishes, and the golden harvests of this grand region prove a source of wealth, less variable than the washings of its blue clay or the crushings of its quartz reef.

In 1851 a rush was made from California to the rich fields of Australia. Mr. Hargreaves, who had been in California, was the first to observe the resemblance which the rocky regions of Australia bore to the gold fields he had just left. A month or two of research paid him with good finds of gold. A native shepherd soon after found a solid mass of gold, and wide fields were quickly worked by myriads of diggers.

Australia, like California, has recovered from her gold excitement, and while her settlements have grown to the size and energy of an empire, her fields of grain yield returns richer than her harvests of gold; and her golden fleece, from millions upon millions of fine sheep, is not less fabulous than that of Jason and the Argonauts.

In times long gone by, a sheep could be bought for a few pence, and laborers worked for a *penny a day;* that was because gold was so scarce that a great deal had to be given in exchange for it.

Now that gold is more plentiful, wages have risen

and our daily wants cost many times as much as in the days of its scarcity.

Gold is nearly as soft as lead, and so easily spreads out under the hammer, that a single grain may be extended over fifty-six square inches; and so thin that *twenty-five thousand folds of the leaf go to an inch of*

thickness. This quality is called *malleability;* the man who thins out the leaf is called the gold-beater. The gold leaf is used by the picture-frame gilder, the writer of gold letters, and for ornamental work in our homes. Gold has another quality; it is *ductile*, that is, it can be drawn out into fine wire. A grain is

sometimes stretched to a length of five hundred feet for the fine wire used in making gold lace.

Because it possesses these qualities, it is above all other metals adapted for money. In some countries of Europe gold is the only money; silver and bronze being coined as mere tokens to represent the fractions of the gold coin.

But all the gold is not made into money. Science, art and commerce make new and large demands upon the supply every year, while bills of exchange and bank checks lessen our need of coin. The amount of gold, therefore, coined at the mint into money is only a very small part of the gold produced.

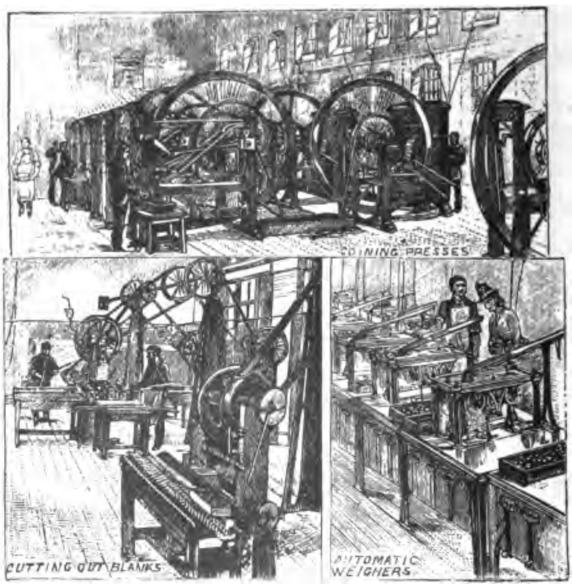
The minting or coining of gold is kept closely in the hands of the government.

The building where the coining is done is called the Mint.

The Mint has always been one of the sights of Philadelphia. It is hard to believe that the great crucibles of molten metals, that come one after another so rapidly from the glowing furnace, contain real gold; that the heavy yellow ingots piled up like bricks can be the same precious metal cooled down. Then when these ingots are drawn through the rolling mills into strips of ribbon cut into lengths and carted off in truckfuls, again it is hard to realize that a fortune goes with each truckful; a fortune so large it would

be enough and to spare not only for our own lives but for our children and grand-children.

The lengths of gold will next be cut into disks or blank coins; next they will be put through a machine which will roll the edges and produce a rim; then



THE MINT.

comes the stamping them with the design and their value. Before a single coin can start from the Mint on its travels about the world, it has to be *assayed*, that is, *tested*, to see if its weight is exactly right. If a coin is lacking in the slightest part of a grain, it is detected at once.

PERUVIAN SILVER MINE.

SILVER.

SILVER is the whitest and most lustrous of all the metals, as well as the most malleable. Its grain is so close and clings so firmly, that beaten silver spreads out into a leaf two-and-a-half times thinner than that of gold. The metal is ductile, too, and the wire, drawn out into marvelous fineness, is in great

demand for silver lace. When pure, silver is a soft metal, but hardens when with alloy.

Veins and masses of it occur all over the earth. In Mexico the richest workings are in connection with a single vein which is one hundred and fifty feet wide. It is rarely found pure, and then in only small quantities. In nearly all silver ore there is some gold, and in nearly all gold ore, some silver; silver is often found with lead, copper, mercury, and cobalt.

Different countries use different ways of extracting the pure silver from the ore. The people of Mexico, of Peru and Chili use the following method:

The pounded ore is ground into a fine paste with water; this paste, after having been allowed to dry up a little in air, is placed on a stone floor with a quantity of salt and the two are trodden together by mules. The next day is added a kind of sulphate of copper, also mercury, and the mules are kept going until the silver is changed as far as possible into amalgam; this takes from fifteen to forty-five days.

After the amalgam is made the next thing is to drive out the mercury; this is done by means of heat and the remainder, by a refining process, becomes pure silver.

The chief silver-producing countries are the United States, Mexico, Chili, and Peru. Mt. Potosi in Bolivia, 2697 feet above the level of the plain of the city

of Potosi, has been mined up to within one hundred and twenty-five feet of the summit and seems to be almost a mass of silver ore.

The great silver mining industry of the United States had no existence before 1860. The gold seekers who wandered over the Western States between the years 1850 to 1860 looking for gold, discovered the silver unexpectedly.

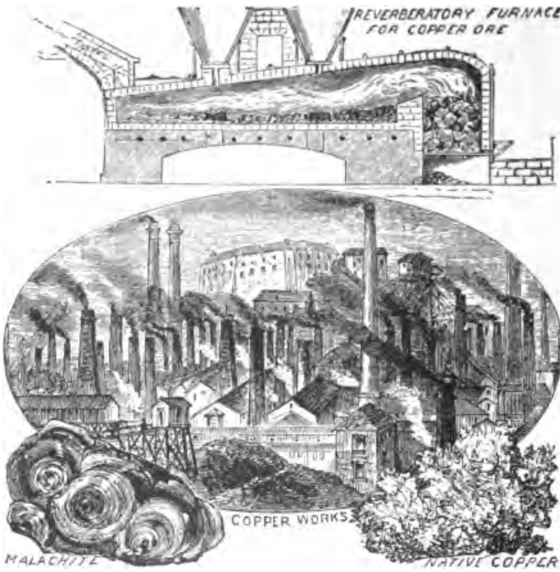
One of the greatest silver mines ever known, the Comstock mine at Virginia City, Nevada, was found in this way, about 1859, by two men, James Shinney and Henry Comstock. Not knowing the value of their great discovery, it is said that they sold it for a trifle.

See how useful a little knowledge is to us, often at unexpected times!

After this it soon came to be known that the mountains of Colorado were full of similar veins.

Pure silver is too soft to make durable coins or vessels which shall be light and firm. This is remedied by alloying it with a little copper. Almost all of what we call "silver" articles are formed of this alloy.

The great use for silver, apart from coin, is for plate. A great deal of silver is now used in electroplating, so that silver plated articles are enjoyed in tens of thousands of homes where solid silver could never be hoped for.



COPPER.

THE baser or common metals, as all but silver and gold are called, make up in quantity for what they lack in quality. The United States is well supplied with metallic treasures, both in beds, as those of ironstone, and in veins or lodes, as those of copper and lead.

Copper, from the Latin *Cuprum*, so called from its prevalence in Cyprus, is one of the most widely

spread of all metals. It is all the more useful for being capable of combining with other metals, thus forming compounds of more importance than pure copper. Brass, bronze, gun-metal, bell-metal, sheathing, white copper, and German silver are all alloys of copper, with more or less of tin, nickel or zinc. Copper is also used to harden gold and silver.

Copper ores are found in the Ural Mountains, in Great Britain, Sweden, Germany, and France. South America, however, ranks first in copper supplies. Masses of almost pure metal, many tons in weight, are scattered over the pathless Andes, useless, because there are no means of carrying it to the sea-ports.

The metallic veins, almost without exception, run east and west; descend to unknown depths, and dip or incline their planes of surface north and south. This, of course, makes easier the work of hunting for metal; it also leads us to think that magnetic action has had something to do with the deposit. These veins look like the cracks in clay soil, split open by the heat of the summer suns, and are filled sometimes with metallic ores.

The ore, as it comes to us, is in the form called crude copper, from which much of the earthy matter has been crushed out, in order to reduce the weight and bulk. Russian malachite, a beautifully-veined green marble capable of splendid polish, is an ore of copper.

It is often worked in small pieces as a gem, and slabs of it are sometimes dressed and polished. Copper, when struck with a hard object, gives out a rich metallic sound. Copper-smiths and boiler-makers ply their craft amid a deafening tintinnabulation of hammers. The beating of the metal gives strength and a closer grain; and as the beaten plate can be riveted with any other metal the malleable heads of the copper rivets spread out under the blows of the hammer and secure a good fastening.

Cooking vessels of copper are in great request. Such utensils have to be kept extremely clean in order to avoid verdigris and other poisonous salts which you have often seen on old copper, and which, without this care, form upon the surface and eat into the metal. As an extra safeguard, copper pots and pans are coated with tin, silver or enamel.

Copper ore is troublesome to reduce. Smelting includes many and long operations of wasting and melting the ore, and refining and toughening the metal.

Copper was certainly one of the first metals subdued by man. Combined with the tin which the Phœnicians obtained from Cornwall, it became the brass of the ancients. This was not the same compound metal which we call brass, — which is made from a mixture of copper and zinc, but was more properly bronze,

capable of taking a keen edge, suited to cutting instruments and weapons of war. Corinth was famous for its works in brass, and at the destruction of that city, so many statues were melted, that the streets, it is said, *ran with molten brass*, and the compound was long afterward celebrated as Corinthian metal.

The Colossus of Rhodes was an image of bronze, weighing 320 tons, striding across, from bank to bank, an inlet of the sea, and under the legs of which ships could sail with their masts standing. This Colossus was thrown down by an earthquake. Bronze was for many ages employed by the Egyptians, Greeks, Romans, and the Chinese. It was this alloy which gave the name to the Bronze Period; the age between the earliest historical division of time, called the Stone Period, and that of the Iron Period, which came after.

Bell-metal and gun-metal are varieties of bronze. They are the foundation of the flourishing crafts of the bell and the cannon-founder. Applied to artistic work, these alloys have produced a great many ornaments such as chandeliers, fountains, and statues. Brass, properly so called, is more in use than any metal except iron. Brass-founders and braziers were renowned for their art workmanship in the Middle Ages. Their church fittings, funeral brasses, and monuments are not excelled with all our present skill and knowledge.

BRASS AND BRONZE WORK.

EVERY one of the compounds of copper is put to a variety of uses. Bronze is made with one part only of tin. With two parts of tin it becomes gun-metal, tough enough to bear the strain of firing cannon of heavy calibre. A third proportion of tin gives it fluidity for the casting of bells. A little lead added produces a soft compound, that can be cut with a sharp tool.

Brass-founding is, likewise, but the first in an almost

endless series of arts, each of which has its own history. Brass is malleable, tenacious, and ductile. Brass plates are rolled, tubes soldered, and wire drawn, each by a distinct trade. Brass-finishers, fitters, engravers, pin, thimble, and button-makers, lacquerers, and artists in brass, and many others, depend for their livelihood and usefulness to society upon brass, and the excellent qualities which the compound metal posseses. White metals, upon copper as a basis, and serving the purposes of silver, with which they are plated, call into being many extra divisions of labor.

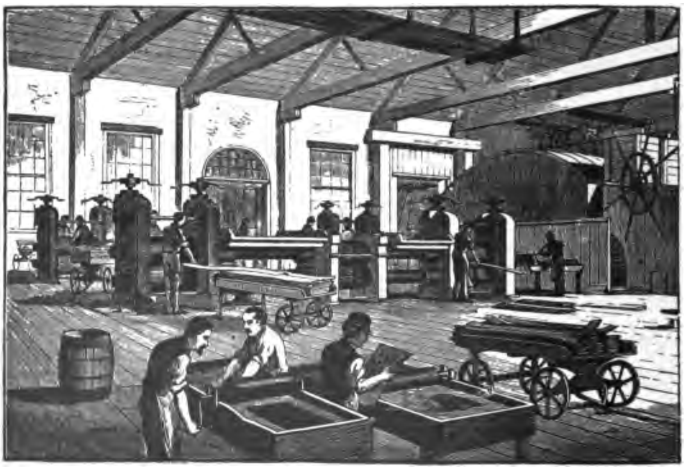
If you should some day make a visit to Waterbury, Connecticut, you would find there one of the oldest established brass manufactories in our country and one of the largest in the world.

From side to side of the great foundry building runs a bank of small, low furnaces, twenty-one on each side. What monstrous dinner can be preparing? Over the fires are forty-two kettles or crucibles, each holding *more than a hundred pounds.* We peer in. The smoking caldrons are full of copper ore from Lake Superior. Each crucible is covered with charcoal and fitted with a sliding cover at the top. Almost all the "casting," which is the name given to the melting, etc., of the brass, we shall see here, is the making of small slabs, flat bars and hollow cylinders.

When the metal is properly melted, the men tip it out of the crucibles into iron moulds.

Here is a picture of the room where the slabs for sheet brass and the flat bars for wire are rolled.

The copper taken out of the moulds, as soon as it is cooled, has rough jagged edges. These must be



ROLLING BRASS PLATES.

trimmed; and with what sort of an instrument do you suppose it is done? With *shears*, so immense, that one great arm of them, working up and down, weighs *a ton*. Of course no hand could work such enormous shears, so they are moved by powerful levers.

The thick bars and slabs of brass are trimmed by them as easily as you can cut a paper kite. The bars

are first passed through one set of rollers, then another, until the sheets are thin enough for use.

Between the rollings, the bars and slabs are annealed, that is, laid in a space between two fires until they are red-hot. Then they are drawn out to cool slowly in the air. This heating is to make them soft and easier to work upon.

Just before the last rolling, the surface of the brass plates are scratched over and cleaned, "over-hauled" the workmen say, so that they shall come out of the last rolling as perfect as possible.

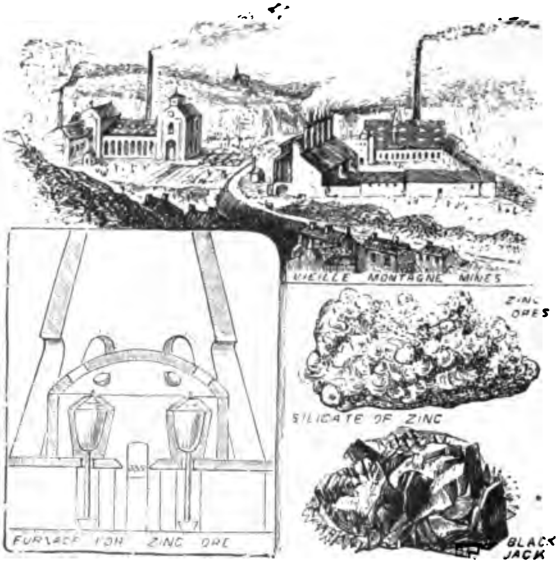
In another room the bars are drawn out into wires for thousands of uses.

For the seamless tubes the metal is poured into moulds in the shape of a cylinder, and having a core. The cores make the tubes hollow. These hollow tubes are put through one drawing machine after another until they are the required size.

Many of the gas, steam and water pipes are of cast, wrought or malleable iron, but brass, too, is used.

At Bridgeport, Connecticut, there is a foundry where every variety of valves and fittings are made. Very likely the faucets in your home or school-house were made at this very foundry.

Look at the faucet a moment and you will see that it is made up of small pieces fitted together with the greatest nicety. It took many skillful workmen to make each of those pieces, and to polish and join them.



ZINC.

THIS is a bluish-white metal. Its existence has been known from early ages, but extracting it from the ore has only been practiced from the beginning of the eighteenth century. It is never found in a pure state. Zinc ore goes under the commercial name of spelter. Three-fourths of the product, to-day, comes from Germany. Belgium, Sweden and the United States also produce it. Two

hundred years ago, the metal was brought to Europe from India. Now much larger shipments are sent from Europe to Asia, and to the remotest parts of the globe.

Zinc has become so important all over the world that it ranges, among the useful metals, — next to iron as a national treasure in its cheapness and the many purposes for which it is used.

Zinc is not very malleable at its natural temperature, but when heated it can be rolled into sheets or plates, and be drawn into wire. Zinc is of great value because it can bear for a long time exposure to the air without change or rusting. This makes it a good and cheap substitute for lead in lining tanks; for house gutters and rain pipes. It bears casting well, and is much cheaper than brass or bronze for statues and ornamental scrolls.

Zinc plates are often preferred to the dearer brass for the inscriptions on shop fronts and doors; they take the place of copper and steel for photo-engraving of pictures and of music, and of stone for lithographic printing.

Zinc, like tin, coats the iron so completely as to form plates and wire, said to be galvanized, which are strong as iron, yet defended from rust almost as well as if pure zinc. The plates are often corrugated or wrinkled — that is, shaped in ridges and furrows,

a process that adds to their strength, and the plates are riveted with zinc nails.

The wire does us service as garden netting, but far beyond this in importance is its application to the electric telegraph. Zinc wires stretch over the houses, and from post to post along our railways, for thousands of miles, carrying our messages with the aid and speed of lightning.

Two of the compounds of zinc are of great industrial value. By its union with copper, it produces brass, an alloy which is applied in more ways than either of the metals of which it is compounded. Zinc-white is an oxide of the metal, resulting from its blending with oxygen, which takes away entirely its metallic appearance, and changes it into a substance as white as milk. Mixed with oils, zinc-white is used by painters instead of the poisonous white-lead, or oxide of lead, the fumes of which cause the workmen to suffer from a painful complaint, known as painter's colic.

Preparations of zinc are of great value in medicine, and we could hardly do without the apparatus and instruments of science with which it furnishes us.

LEAD.

LEAD ore, in which is often found silver, is abundant, too, in every division of the earth. When melted or when freshly cut, it is bright and shining like silver, but it soon tarnishes. Lead is the heaviest and one of the softest of baser metals. It is malleable and ductile, but not to such a degree as other metals.

Lead ore goes through the usual operations of pounding and washing to get rid of the earthy parts, before going into the smelting furnace. This furnace is so built that the flame is made to beat back upon the surface of the lead, hence it is called a reverberatory furnace.

The roasting is done by a gentle heat at first in order to drive off the sulphur, then the heat is raised and the liquid metal flows out.

The melted lead pours into an iron pan. The impurities, being lightest, float on the top and are skimmed off. Then the clear metal is ladled into iron moulds, and cools down into pigs of lead. Sheet lead is now produced by the rolling mill. The sheet is then folded up like a bale of cloth. Pressed still thinner to the thickness of a leaf, it is called lead-foil, a vast quantity of which is used in China and India for lining tea-chests.

Pewter may be said to be an alloy of lead and tin; sometimes small quantities of copper and zinc are added. Before modern pottery gave us cheaper and better wares, pewter platters gleamed on kitchen shelves now laden with earthern plates and dishes of every color and design. By adding antimony still greater hardness is gained, and the alloy is known as Britannia metal. It is then fashioned into tea and coffee-pots, dish-covers and salvers which, when polished, are

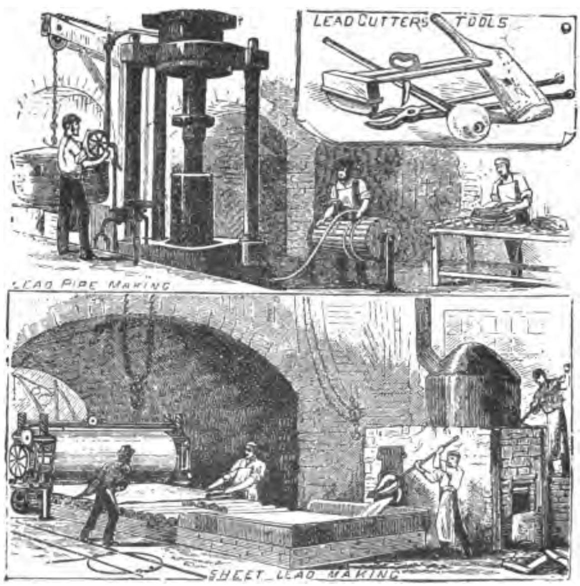
hard to tell from silver. Thousands of operatives in England earn good wages by making these ornaments for our tables. A similar compound is used for printer's types and stereotype plates.

Solder, type metal, and the poisonous white-lead, are compounds of lead. Two parts of lead to one of tin makes the plumber's solder for making joints and unions in lead pipings. Soft solder is made of two parts tin and one of lead. The soldering-iron or tool for cementing is a bit or tongue of copper, fixed in a short shaft of iron.

Copper is chosen to melt the fusible solder, because copper retains its heat for a long time; the solder is still more readily made to flow and spread, by a flux of powdered rosin and borax sprinkled over the work. Soft solder and soldering-iron are ever at the hand of the brazier, the tinman, and the travelling tinker, who could not get on without them. A neater plan of soldering with the blowpipe, for finer work, does away with the soldering-iron altogether.

The work in lead, after it is in the shape of sheet-lead and lead pipe, belongs to the department of the plumber, who employs it for roofing, for cisterns and for lining. Occasionally, where the traffic or friction of many feet is great, such as office passages and stairs, the sheet of lead is unrolled and laid as a carpet. Shot is made by pouring melted lead through

a sieve, from a great height into the water underneath. In the descent, the shot becomes globular, on the same principal as drops of rain assume that form in falling. The idea, so it is said, came to the



mind of the inventor in a dream, and he first tested the suggestion from a tower. It is more likely that the thought had been working in his mind a good while before the lucky dream put it into shape. Lofty shot towers are now well known objects in various places.

A TIN MINE.

TIN.

TIN is rather a scarce metal. It is found in Cornwall and Devonshire, England; in Germany, Bohemia, and Hungary, in Europe; in Chili, Mexico, and the United States in America; in Malacca and Banca in Asia.

English tin is the best in quality, though that from Banca is nearly, if not quite, as pure. The tin mines

and smelting works of Cornwall are so numerous, as to form a marked feature of that ancient and interesting county.

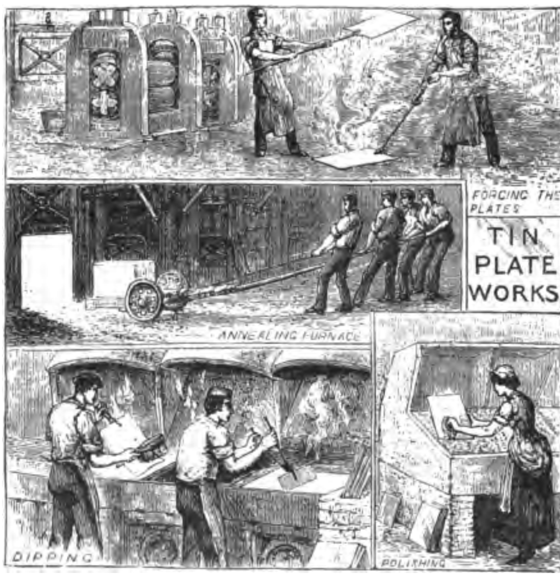
Tin ore is worked in Australia, and lodes of marvelous richness have been found in the Wild River range of the same country. Tasmania is famous for its rich deposits.

Tin ore occurs in two conditions — that of tin-stone, in veins, combined with other metals, and of stream-tin, brought by local streams from the neighboring rocks, and deposited in the river mud or alluvial soil. By roasting, smelting and refining, the ores are converted into metal, and run into pigs — the tin-stone yielding bar or block-tin, and the stream ore a purer form called grain-tin. The smelting and refining of tin is easy compared with copper, and is done, as we have seen, on the spot where it is found. Stream-tin has a higher value than the bar or block-tin, produced from other ores.

Tin is so malleable, that leaf or foil, less than the thousandth part of an inch in thickness, easily rolls out. The foil is of service in many ways, from folding sweets, tobaccos, and other simple commodities, requiring to be kept cool: the lining of tea-chests and work-boxes, to coating Leyden jars and electrical glasses; and aiding in the researches of science and philosophy. Tin bends easily, and with a queer,

crackling sound, unlike that of any other metal. It alloys with many of the metals, making them more brittle.

Tin plate, or iron coated with tin, is the most useful form of this metal. Thin iron is dipped into tanks



of melted tin; in a short time, the tin, like zinc, has eaten its way into the iron and lo! there is a new metal, having the strength of iron and all the brightness and cleanliness of tin.

This tin-plate is in great favor. The tin-plate worker, with a few simple tools, such as shears, mal-

let, wooden blocks and soldering-iron, frames a countless number of articles, mostly for kitchen work, and at so cheap a rate the poorest families can afford them.

The world's supply of tin is estimated at present at the rate of 56,000 tons. Of this England only produces 9000 tons; Australia, 6,500 tons; the Malay Peninsula and islands, 28,000 tons, and all the rest of the world makes up the balance of 12,500 tons.

We have at least one assured American tin mine. The Temescal tin mine, in California, produced the first American tin ever sent to the market.

This mine is situated in the Temescal Hills, a part of the Sierra Madre Range, only a few miles from the Santa Fe station at South Riverside, and promises to be a valuable and productive property.

There are about thirty lodes or veins, only one of which is being worked as yet, and the amount of ore handled daily is something over thirty tons, the tin metal product being about three-fourths of a ton.

In the Black Hills of Dakota there are also tin mines which are giving promises of a rich production.

IRON MINE.

IRON.

DID you ever think, when you were driving nails into a piece of wood or when you have picked up a "lucky" horseshoe on your way to school, what we should do without this hard, strong metal?

It makes, equally well, a needle and a gun; a pen and an armor-plated ship; the hair-spring of a watch and a steam engine; a bead and a bridge; a tiny spangle and a mighty anchor.

The same ore furnishes the cannon and bomb, the sword and the plough-share; the chisel and the chain. Most of us know by "bitter" experience that it is used in medicines. It has been well said that iron and coal are kings of the earth.

Iron is of a bluish-white color, and is very brilliant when polished. It is harder than most other metals, and increases in hardness when changed into steel. Almost every mineral contains some iron; all over the world it is found, but the United States has a chance for an iron industry, unexcelled by that of any other land. In our country the sixteen States in which ores

Magnetite:
- black,
- hard enough to scratch glass,
- when powdered, black,
- magnetic.

Hematite:
- dull red or shiny black,
- may be scratch by a knife,
- except when black,
- powder always reddish,
- not magnetic.

of iron are found most abundantly, are: Pennsylvania, Ohio, Alabama, California, New York, Virginia, Tennessee, Michigan, Wisconsin, New Jersey, West Virginia, Massachusetts, Maryland, Kentucky, Georgia, Connecticut.

The three most common ores are:

Brown Hematite: { yellowish, or dark brown,
scratched by a knife,
powder yellow or brown,
not magnetic.

Sometimes the iron mine is just a huge ditch; then it is called an *open cut* mine. At other times openings called *shafts* are dug like well-holes, straight downward; from the bottom or sides of these shafts tunnels called *drifts* are made in different directions; these drifts are what are called underground mines. The ore loosened by the miners with pick-axes or by blasting, is drawn out of the mine and sent to the furnace to be smelted. All iron ores go through processes of reduction. The more impure they may be, the more work must be done to rid them of the carbonic acid, water and combustible matters. This is done by roasting. To produce foundry or cast iron, layers of roasted ore, of fuel, and of limestone, are wheeled in barrows and toppled over, one upon another, into the kiln, until filled to the top. Then the hot blast is applied, and the rest of the earthy matters, with the oxygen of the ores, is set free, while the melted iron sinks to the bottom, where it collects, until a plug or sluice is lifted, when the metal runs off in a stream of fluid fire. The main channel into which it is cast is called a sow, and the smaller sidings are called pigs,

from a fancied resemblance to that animal with a litter of young ones.

Sow and pig iron are of three qualities. The best is grey iron; the second mottled, and the third white. These qualities and consequent values are derived, as

A SCENE IN THE IRON COUNTRY.

much from the fuel and mode of smelting, as from the character of the ores. Foundry iron needs no further preparation for castings, the best quality running into the most delicate and beautiful tracery. Cast iron is brittle and breaks under the hammer. In order to

convert it into wrought, bar, forged, or malleable iron, it has to be refined by remelting with coke or charcoal; this process drives off any oxygen and carbon which may have been left, and brings it to the state of fine metal, losing about a tenth in weight. The process is completed by a puddler, at a like cost in weight of metal. Then the blooms of globular masses from the puddling are forged under the heavy steam-hammer, passed through rollers, drawn out into bars, cut into lengths, and formed into bundles; again brought to a welding heat, once more hammered and rolled into rounded, squared, or fluted shapes, ready for the market.

If we want to see and understand what labor really means, how the wealth of the country depends upon it, and how mind can direct the hands, we must visit our iron-works and watch our iron-workers.

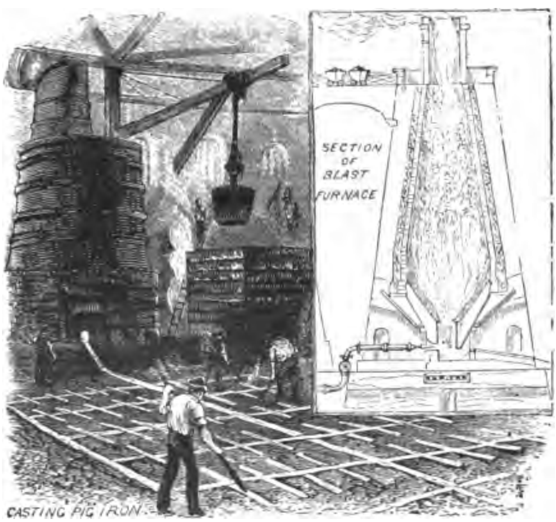
A region better fitted to wake up "dozy folks," or to delight people who love wonders, cannot be found than the iron fields of our country. To view the fires of such a field by midnight, when the flames glare against the dark sky is a strange, grand sight.

Enter one of the great iron-works and feel the red lava slag close enough to scorch your face.

See! hear is real iron kneaded and rolled as easily as Jennie kneads the bread at home; here iron is cut like clay, and twisted like wax; red hot it is

poured into moulds. Livid rivers, from the furnace, flow in a cascade of fire to fill large pots brimful, and to be hurried off by men flitting hither and thither and looking like demons in the red glare.

Can this be iron? Plate upon plate of every thickness, but no thinness, spread out for causeways or



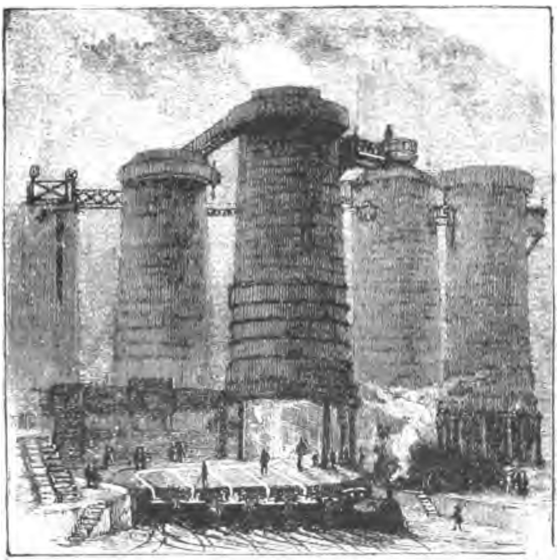
piled up in dozens, are before, behind and upon either side. Pillars and posts are scattered about, heavy and massive. Iron, iron, iron everywhere. We pick our steps in and out among the lengths and breadths of metal. Ridges of glowing metal are here, long stretches of framework there; the loose bones, before

being jointed into some mighty machine — liquid it may be, white-hot, red-hot, black-hot, dull, gray, or cold.

Iron works upon iron. Here are steam-boilers sputtering, and engines cutting, sawing, hammering, planing, slotting, sliding, drilling, turning metal. We witness a scene without equal in the realms of industry. It makes one's eyes open wide, to see tools play upon iron as if it were an easy yielding thing. Resistance appears no more to be thought of than if it were India-rubber or gutta-percha. While we can count one, two, three, a row of rivet-holes, an inch wide, for a steam-boiler, are punched in a thick sheet of iron; the well-tempered punch passes through the solid iron as though nothing stood in its way. That there is a pressure, you may be sure, for each punch gives a gun-shot report, and picking up one of the boy's "nickers," fallen from the hole, you drop it in a hurry. It blisters your fingers. Cutting it has made it too hot to hold; yet cutting from the cold iron takes less than a second.

On the summit of a blast furnace, a hundred feet high, the sweltering heat can hardly be borne as it rises from the sandy gridiron below, into whose narrow gullies the red-hot metal runs, from the open sluice at the foot of the iron tower. Yet men learn to sustain the fiery heat, which overhangs the white-hot plate,

the "wagon" filled with ten tons of molten steel, and the moulds into which the pig iron crawls crimson-red from the furnace. In the rolling-mills, huge blocks of white-hot metal, beautiful with greenish vapor-like flame, are hauled about as sailors drag a chain cable;



BLAST FURNACE EXTENSION.

thrust into the jaws of the rolling-machine, passed many times to and fro, and finally brought out as armor-plates or steel rails. Use toughens the skin of the swarthy workers, who stand by the blinding metal, overhang it, or jump across, and dodge about it, while the crimson splendor shines from their wet

faces and half naked bodies, and they themselves look like shapes of fire.

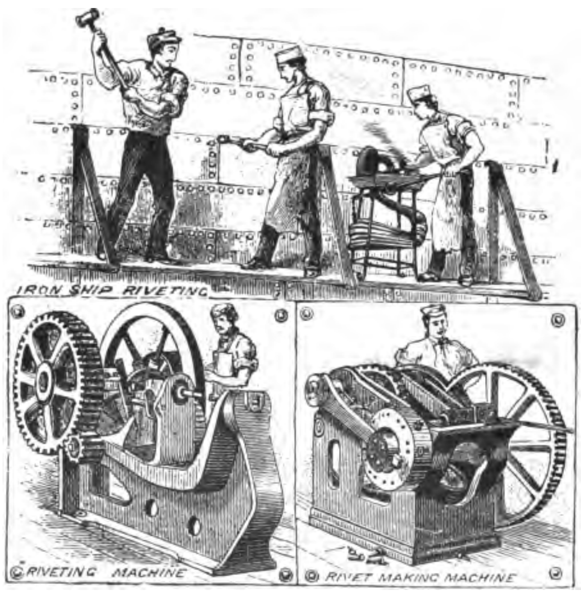
Now come into the factory among the forges and smiths. Everything here is black but the glancing fires. Even so crude a thing as a forge has a symmetrical beauty of its own, and here are, say, twenty at work. Anvils cover the ground. Three of the men take a red "heat" from the fire and belabor it with sledges. Round and round overhead the sledges fly; one after another they crash down upon the anvil like a peal of church bells; each hammer-man measures its distance by his eye and the force by the smaller hammer of the fireman, which rings in between their blows.

You think perhaps the man who directs the work hammers his anvil more than he hammers the iron, but the hammer-man knows there is a meaning in it. When the single or double tap, or the long ring is given on the leader's anvil, each hammer-man knows whether to give a weak or strong blow.

Now the "heat" is off to the fire again and we can drop our anxiety for the men's heads. It did seem as though they could not escape those sledges which whizzed close to their ears. So precise, however, is the practice, that a good hammer-man never misses his mark by half an inch.

Here are the riveters at work, bolting together the iron sheets of a steam boiler, or the massive plates

of a huge ship's hull. Hammers, striking by the hundred, keep up a cling and a clang that forbid speech. As a city is built, one brick at a time, so a boiler or a hull draws nearer completion with every driven bolt. Leaning backward and sending well-



directed aim, they play a duet with heavy hand-hammers upon the red bolt just drawn from the forge. With the skill and force of Old Thor, they drive it home into the hole punched for it by the machine whose miracles of punching we saw a while ago. Labor it is in the true sense, heavy, hard, manual

labor with an end in view, and that end *human welfare*. Nothing else is properly labor.

MUSIC OF LABOR.

THE banging of the hammer,
The whirling of the plane,
The crashing of the busy saw,
The creaking of the crane,
The ringing of the anvil,
The grating of the drill,
The clattering of the turning lathe,
The whirling of the mill,
The buzzing of the spindle,
The rattling of the loom,
The puffing of the engine,
The fan's continual boom,
The clipping of the tailor's shears,
The driving of the awl —
These sounds of honest industry
I love — I love them all!
The clinking of the magic type,
The earnest talk of men,
The toiling of the giant press,
The scratching of the pen,
The bustling of the market man
As he hies him to the town,
The halloo from the tree-top
As the ripened fruit comes down,

The busy sound of thrashers
As they cleave the ripened grain,
The husker's joke and catch of glee
'Neath the moonlight on the plain,
The kind voice of the dairyman.
The shepherd's gentle call —
These sounds of honest industry
I love — I love them all!

BITS OF KING IRON'S HISTORY.

THE stores of iron ore are not a new or recent gift of Nature. The iron was in the rocks for ages before our land was peopled. In England the smelting of iron succeeded that of tin. The Romans practised the art. The Saxons neglected mining of every kind, yet we are told that at Hastings, Harold's horse-soldiers were cased in armor.

Mining, for centuries, was performed with hammers and wedges.

The mining works were conducted on the sides of hills, where the natural drainage answered for removing the water that collects in a mine. Adits, or passages, were driven into the rock, following the veins, as far as was safe, and then the mine was forsaken.

Shafts and lifting machines, and adits driven underground to the places of working, in after periods, increased the yield of ores; while larger furnaces, with plugs to run the metal off, turned out greater quantities of pig iron or other metal.

The wars and manners of mediæval times gave great scope to the skill of the iron workers. Great pains was bestowed by the sword-smiths and armor-

HORSE-SHOER.

ers upon their work, some of which has been kept until now, and cannot be excelled.

Lock-smiths and ornamental iron-workers of those days made bolts, bars and bosses for the church doors.

The first horse-shoer lived in the Middle ages; before his time horses were shod with leather. As new highways were made, farmers' wagons, never thought of when the roads were few and bad, brought

the wheel-wright and coach-smith forward with their need of iron.

Without the forging of iron, Pascal, who lived in the seventeenth century, would not have had the idea of a wheelbarrow.

When he invented a wheelbarrow to save the toil of carrying heavy baskets, he little thought that his humble invention was the germ of the world's great wheel traffic of to-day. Iron gave birth to traffic on wheels; wheels widened interchange, and interchange has brought us the knowledge of the world in which we live.

Cast iron was not in common use before the year 1700, when Abraham Darby, of England, thought that iron might, in many cases, take the place of brass in founding. He had in his service a Welsh shepherd boy, named John Thomas. Whilst looking on during the experiments, the shepherd boy thought he saw where Darby missed his mark and begged to be allowed to try. The two remained alone in the work-shop all night, struggling with the stubborn metal and poor moulds, but, just at dawn they succeeded in casting an iron pot, and another of the great secrets of nature was solved. For more than a hundred years after the night when Darby and Thomas cast the first iron pot in a mould of sand contained in frames with air-holes, these two of our world's benefactors and their descen-

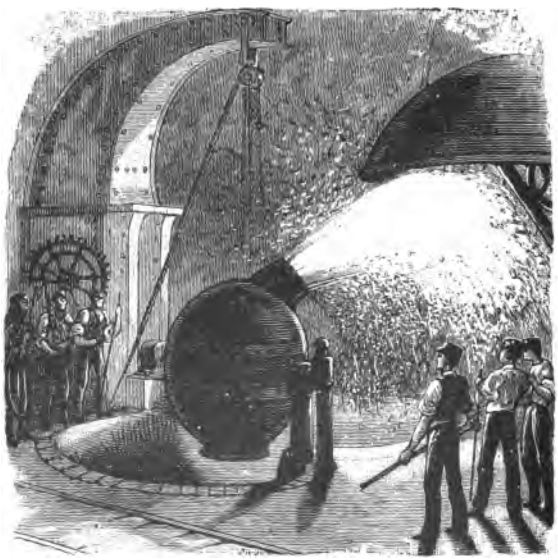
dants, pursued the same process and kept the secret, with plugged keyholes and barred doors, at the since famous iron-works of Colebrooke Dale, England.

Some of the greatest inventions of human genius and thought divide King Iron's history into epochs.

The first of these was the cupola or dome-shaped furnace, devised by Cort in 1784. The object he succeeded in was to cause the flame, instead of acting directly upon the mass of metal, to curve round the roof, and play upon the surface of the charge. The puddler, who conducts the operation, constantly stirs the charge laid upon the floor of the furnace, so that every part, in turn, shall be presented to the oxygen of the blast, and the carbon of the iron shall be quite consumed. This puddling or stirring is, perhaps, the hardest manual labor known to industry. It is done by men, working nearly naked, because of the glowing heat. They keep stirring the fluid metal, until it loses the liquid condition and assumes that of a pasty mass, which they work up into balls or blooms, and ladle out of the furnace. An engine, during the whole time, sends a blast of air forward, which cannot be arrested for a moment without injury to the metal. While the puddlers stir the sticky blooms about, so that each lump may come to the flame, they must change their rakes from time to time, so that they, too, may not melt. Such furious heat plays so upon the

puddlers that their eyes get bleared, and their faces blistered.

Now puddling by machinery has, in a great measure, taken the place of manual labor. American inventors have contrived revolving furnaces. A "squeezer" does

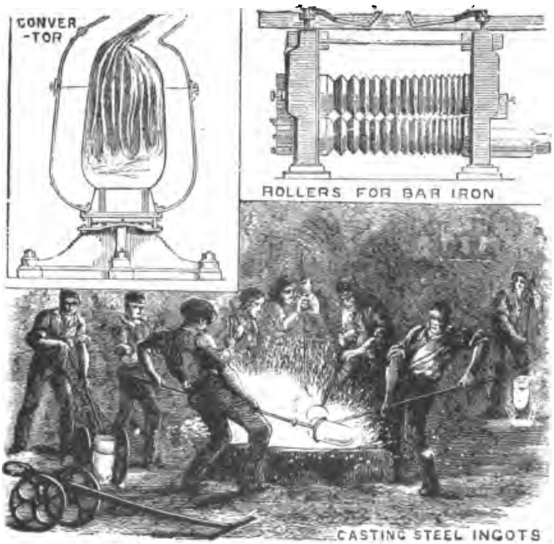


BESSEMER PROCESSES.

all the dreadful back-breaking, and the rotary furnace turns out four times as many blooms as by hand labor. Science has come forward at a time when the men, knowing how quickly puddling killed them, had begun to abandon their trade. We shall now be able to get bar

iron without having to think of "the martyrs whom the fire slew."

In 1829, Neilson introduced the hot blast in place of a cold blast, and brought air to the metal, at once ready for the work it had to do. As a result, the yield of metal increased at the rate of two



to one, and a better quality of iron was gained, in less time, and with smaller consumption of coal. Until the invention of the hot blast, the moisture in the air that played on the metal had been an endless trouble and source of uncertainty in puddling — more so in summer than in winter, from the larger amount of moisture absorbed by the warm and dry air.

In 1855 a man named Bessemer invented a method of forcing currents of air or of steam among the particles of molten iron. This process made the metal malleable and gave it some of the qualities of cast steel. So simple is the process that we wonder why it had not been thought of before.

Long ago, before railroads became universal, it was thought that fine steel must be brought from England: but now our steel industries have improved so much that our own steel is as good if not better than that imported.

Come into the steel-works of Pittsburg. What a whirr and clatter and roar!

Trip-hammers pound, engines puff and rattle. See how the furnacès glow with white heat, and how the heated iron or steel flashes as it is drawn out!

Immense shears are here, too, clipping great sheets of iron.

Over there vast grindstones are smoothing and polishing plow colters.

Not far off, men with wet cloths wrapped about them to keep bodies and clothing from burning, stand over the slits above the furnace.

With long iron pincers they grasp the pots of melted metal, lift them out and pour the contents into the moulds.

Before they can turn away from the furnace their wet clothes are smoking from the intense heat.

Everything and everybody here move with so much vim and velocity, and make so much noise, that we think, for a moment, that all is confusion, endless and without meaning. But no one is confused but ourselves.

Each department goes on with its share of the work, smoothly and steadily, without loss of time or waste of material, till the rude lumps of pig iron are changed to beautifully finished steel. Most of the steel bars from which the wires were drawn for the Brooklyn bridge were furnished by a Pittsburg firm.

IRON.

Iron vessels cross the ocean,
Iron engines give them motion;
Iron needles northward veering,
Iron tillers vessels steering;
Iron pipe our gas delivers,
Iron bridges span our rivers;
Iron pens are used for writing,
Iron ink our thoughts inditing;
Iron stoves for cooking victuals,
Iron ovens, pots, and kettles;
Iron horses draw our loads,
Iron rails compose our roads;
Iron anchors hold in sands,
Iron bolts, and rods, and bands;
Iron houses, iron walls,
Iron cannon, iron balls;
Iron axes, knives and chains,
Iron augers, saws and planes;
Iron globules in our blood,
Iron particles in food;
Iron lightning-rods on spires,
Iron telegraphic wires;
Iron hammers, nails and screws —
Iron everything we use.

LITTLE THINGS MADE FROM IRON.

KNIVES.

THAT pocket knife, Eddie, that treasure among your treasures, had quite a history before it came to you. Separate pieces of steel—which you remember is only iron hardened—were pounded and pounded until they were closely welded together in one piece in the shape of a long, narrow bar. The bar was perhaps half an inch in breadth, and about as thick as the back of your knife-blade. The forger took this bar, heated it, and began pounding again. How your eyes would have grown wide open and wondering, if you could have seen him fashion the form and rough edge of what looked like a long knife-blade out of it.

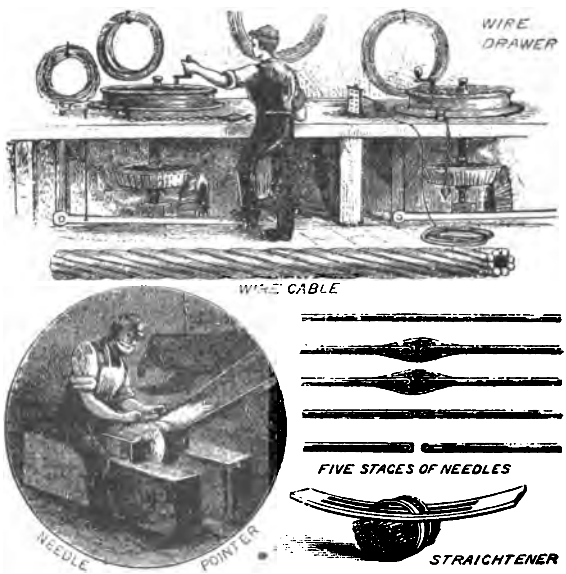
The bar was next cut into short strips; each of these strips—your blade among the rest—was then ground upon dry stone and thus made considerably lighter in weight. Then a piece of iron for the "tang" or shoulder—the iron middle of the handle—was welded on. Back to the forge went the shaped blade again where the maker's name or mark was stamped upon it. To make it still harder, it was heated to a cherry red and suddenly plunged into cold water.

Next came the grinding upon wet stones; with every turn of the round stone the firm blade grew thinner, till, at last, it was "sharp" enough and ready to be polished. The polishing was done on wheels

covered with leather and fine emery. The blade, bright and shining, was at last riveted into the ivory, bone or horn part of the handle, and lo! there was your knife ready for the shop-keeper and for you.

NEEDLES.

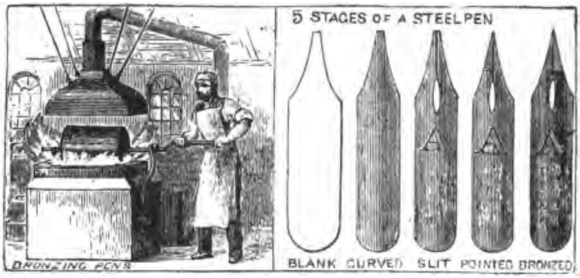
That needle which Jennie is using to piece together the bright bits of patch-work might tell, if it could speak, a very interesting story; — a story of how steel wire was drawn out fine and in great lengths; of the wire being wound in large coils until it was cut with



great, powerful shears into lengths each sufficient for two needles: Of these lengths, curved because of having been coiled, being straightened by being packed in bundles — a thousand or more in one bundle — within two strong, iron rings.

Of how the bundles were heated red-hot, and then placed on an iron plate having two parallel grooves, and worked backward and forward by the pressure of an oblong iron tool — of how the lengths came out of this process perfectly straight and even and were sent to the pointer. How the pointer "sharpened" both ends of the lengths of wire on a swiftly revolving grind-stone, while the poisonous dust flew in every direction. Of how each wire was stamped in the centre by means of dies, with the grooved and rounded impressions of two needle heads; how these were perforated by fine steel punches. How these double needles, about one hundred at a time, were threaded together by fine steel wires passing through the eyes, making them look like fine-toothed combs; how the joinings of the pairs of heads were at last broken by bending. How each tiny head had to be smoothed and rounded with the file before the wire was removed, and the needles, perfect, at last, are sent out to do their work in the world.

Better than gold is a thinking mind
That in realms of thought and books can find
A treasure surpassing Peruvian ore,
And live with the great and good of yore.

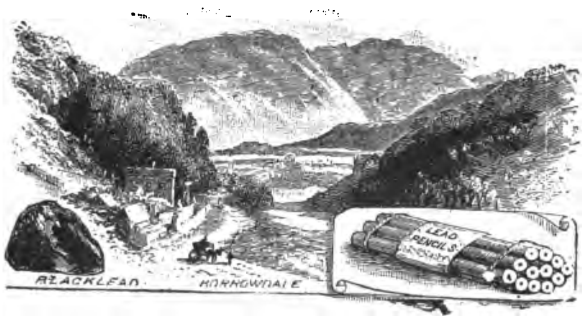


PENS AND PENCILS.

I hope you have wiped the steel pen lying there on your desk, Nellie, for it was a great deal of work to make it. First, steel had to be rolled into thin sheets, cut into broad strips, heated, scoured and rolled again. Then each strip had to be cut into blanks by a "cutting-out machine;" one or more holes were then stamped in each blank as well as the name of the maker. Next the blank was curved by stamping. The nibs had to be made by grinding on an emery wheel; the slits made by peculiar shaped chisel-stampers. Then the pens were heated and scoured, and placed in a revolving cylinder over a hot fire to give them that fine bronze color.

The lead pencil:— do you take it up and wonder if that, too, has a history? It has. You would not

think that the part which is soft enough to "mark with" was a *kind of iron ore*, would you? It is, and is called graphite. This graphite — black lead, we call it sometimes, but the name is incorrect — is cut into thin plates with a saw, and again into strips as wide as the plate is thick. These strips are laid in a



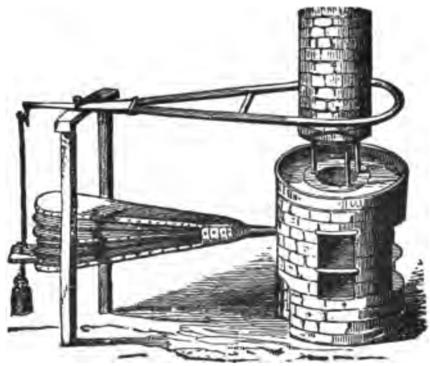
groove in a piece of Florida cedar, and upon this is glued another piece of cedar. The whole is afterward made round by cutters which whirl around at a great speed. These cutters leave the wood perfectly smooth, and there is nothing left to do but to stamp the name of the maker, cut the wood into just the right length for pencils, and bind them in bundles.

NAIL MAKING.

The nail could tell a story that would please you, boys. A story of a great machine fed with hot strips of steel of the right breadth and thickness for nails. Of the way the machine "bites" the strips into the right lengths, clutches them by the neck as they fall, and holds them until it has "banged" the upper end into a head; a machine *which turns out from 100 to 1000 nails in a minute.* Who do you suppose invented such a hurrying, banging instrument as this? *American people, of course.*

But all nails are not made by machinery. Cast nails are made by running melted metal into sand

moulds; so are shoe-maker's hob nails. Horse-shoe nails are made by hand, forged upon the anvil. When every nail had to be made by hand in England, not only the men, but their wives and children, worked all day in filthy sheds close by their homes. The nail master or overseer supplied them with nail rods and paid them for the work done; sometimes in money, sometimes in "truck."



OLD NAIL FORGE.

The nail factories of our land are chiefly in Massachusetts, New York, Connecticut, and the Schuylkill region of Pennsylvania.

There are about three hundred sorts of nails altogether, each of ten different sizes; from the smallest brads and tacks to the heavy rivets and bolts; in all, some three thousand varieties. Nails were made before iron was worked; the first ones being made of bronze. Bronze nails were found in the ruins of Pompeii.

THE VILLAGE BLACKSMITH.

UNDER a spreading chestnut-tree
  The village smithy stands;
The smith, a mighty man is he,
  With large and sinewy hands;
And the muscles of his brawny arms
  Are strong as iron bands.

* * * * *

Week in, week out, from morn till night
  You can hear his bellows blow;
You can hear him swing his heavy sledge
  With measured beat and slow,
Like a sexton ringing the village bell
  When the evening sun is low.

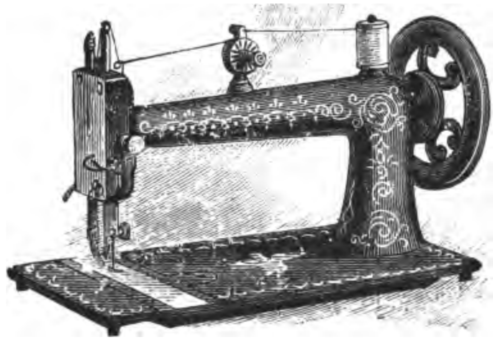
And children coming home from school
  Look in at the open door;
They love to see the flaming forge
  And hear the bellows roar,
And catch the burning sparks that fly
  Like chaff from a threshing-floor.

* * * * * *

Toiling, — rejoicing, — sorrowing,
  Onward through life he goes;
Each morning sees some task begun,
  Each evening sees it close;
Something attempted, something done,
  Has earned a night's repose.

Thanks, thanks to thee, my worthy friend,
  For the lesson thou hast taught!
Thus at the flaming forge of life
  Our fortune must be wrought;
Thus on its sounding anvil shaped
  Each burning deed and thought.

— LONGFELLOW.



SEWING MACHINES.

OLD King Iron has so many children right here in our own country, all inheriting the strength and courage of their father and working away for us in the agricultural and commercial world, that the names and pictures of half of them would more than fill this book. There are hundreds upon hundreds of sewing-machine manufactories, but we will peep into one in New York.

Here we are in one of the machine rooms; here lathe-work, milling, grinding and drilling are being noisily carried on, until all parts of the machine are exactly fitted and properly finished.

Every separate piece has to be inspected and gauged before it can be passed along as perfect.

Many of the working parts of the machine are of hardened steel, so that they shall not wear away easily.

Before the machine can be put together the legs and iron parts are given that hard, polished, black surface by a process called japanning.

This work is done in a room by itself. The japan mixture is put on with a brush in several coats.

ASSEMBLY ROOM.

Between each coat the irons are put into ovens and baked for ten or fifteen hours.

After this process, the pieces to be ornamented go to another department, where decorations in painting, bronzing or gold-leaf are put on, or decalcomanie pictures transferred to them.

In a room called the "assembly" room, all the work

done upon the machine, in the putting together of its parts, is looked over, except that of setting up the tables on their stands.

Near by, is still another room, where "jacking" is carried on. This is simply placing the machines, while being put together, upon jacks and setting them to "running" at a great speed to see if the parts will work. After this each machine is set to sewing a little to see if it is capable of doing the work for which it is intended when it shall go out into the world.

The first attempts at devising the sewing machine were made somewhere about the year 1830, but these were unsuccessful, and the inventors died without gaining any benefit from their labors.

In 1843, Elias Howe, of Massachusetts, invented a machine, which, after many trials, hampered with excessive poverty, he at length succeeded in bringing into use, in 1846.

The story of this man's career, which you would do well to read, is a striking chapter in the annals of intelligent labor, and well illustrates what perseverance will do, by carrying out its purpose through disappointment, hindrance, and want of means, till at length success is reached in spite of everything.

STOVES.

COME into the kitchen and you will meet with one of the most useful of Iron's children. "O, yes, the stove!" you have cried out, long before I could write the word.

The pattern of the stove is first made in wood; from this an iron casting is taken, which, after a great deal of filling and fitting up, is used as a working-pattern. These iron patterns are backed with wood in the same room where the "flasks" or boxes containing the sand for the moulds are made.

The making of machines themselves by machinery was an invention of our American people, and in many of our great cities are immense factories where wheels, boilers, bolts, all the parts of locomotives, flour mills, mining machinery, shafting, hangers and pulleys, and hundreds of similar articles are made.

There are several such manufacturing firms in Ohio, which sends its machines to every state in the Union and to many foreign countries.

The greatest care must be taken to make every part of the pattern evenly balanced in weight, else the castings made from it will be warped and cracked by the heat. Impressions of this pattern are made in the sand in the flasks or boxes.

The melted iron is carried by hand from the furnace, poured into the moulds, or boxes of sand, and allowed to cool.

All the work, except the rough heavy pieces for heaters and furnaces, goes from the moulds to the cleaning room.

In this room they are turned about in revolving drums nearly as large as hogsheads. This is to rub off all the sand left upon the iron. Some of this work is done by hand, the men using stiff steel wire brushes.

The iron is next taken to the polishing room, where the pieces are made bright and beautiful by being ground upon emery wheels and polished upon leather-covered wooden ones.

The nickel-plated parts were polished on these leather-covered wheels and taken to be plated in a room by themselves. A quantity of nickel, a metal something like iron and cobalt, is melted in water, and acid is added. After some further preparation the pieces are put in and the liquid is brought to boiling. In a few minutes the objects are completely coated and are taken out to be burnished on wheels covered with felt and muslin.

In the "mounting" room the stoves are all put together; the parts being made to fit evenly and work nicely.

"So artists melt the sullen ore of lead,
By heaping coals of fire upon its head;
From the kind warmth the metal learns to flow,
And pure from dross the silver runs below."

WATCH MAKING.

WATCHES AND CLOCKS.

WHETHER you are so fortunate as to own a watch,or whether you only hope to own one some day, I think you will like to learn something of its manufacture. Few of you young folks, we are sure, are so thoughtless as never to have wondered at the mechanism of the patient house clock. Clocks are believed to have been in use as early as the twelfth century.

Long years ago,—in the sixteenth century—before watches had been thought of, and when clocks were very imperfect affairs, that great thinker, Galileo, was one day sitting in a cathedral. As he sat

there he noticed that a lamp, hanging by a slender chain from the top of the building, was swinging steadily to and fro.

This set him thinking. He went home; made a pendulum and set it swinging in the same manner. He found its motions so exact and steady that by counting the number of times it moved backward and forward it might be used as an instrument for dividing periods of time. He found, too, that two pendulums of the same length would beat time exactly together; and that a short pendulum moved to and fro more times in a given period than did a long pendulum.

Of course these pendulums could not be used for clocks;— no such idea entered his head, so far as we can find out — because there was no way to keep them going except by "jogging" them, now and then, with the finger; and there was no way to mark the time except by counting; but they did very well for marking the time when making calculations in astronomy, and for that they were used for many years.

But the pendulum once invented, some clever men long afterward thought out a way to keep it going and to mark the time upon a dial.

If we look at the inside of one of our clocks, we shall find it has all these parts:— frame, wheels, pinions, pendulum, and weight. The frame has two brass plates, kept at a proper distance from each other by

four turned pillars; and there are little holes made in these two plates in which the pivots of the pinions turn.

The wheels are made of brass and generally have a number of teeth or cogs around their edges. There are usually four of these wheels — the "great wheel," "centre wheel," "third wheel," and "escape wheel."

The pinions are the small steel wheels which the brass wheels work into and drive around.

The pendulum is hung at the back of the works by a steel spring.

The weight is suspended by a string.

This string is wound upon what is called a "barrel," which is attached to the great wheel.

"Wind up" the clock carefully and you will see that the string of the weight winds itself around the "barrel" until the weight is high up in the clock.

Set the clock going. See, the weight descends a little; its motion makes the "great wheel" turn a little; this moves the centre wheel pinion, and so on from one wheel to another, until the escape wheel moves.

The escape wheel gives the pendulum a slight "push" and makes the "tick-tick," which makes the clock such pleasant company.

The wheels are so arranged that, whatever the length of the pendulum may be, the centre wheel must turn round once in an hour.

The centre wheel and its pinion have their axes long enough to reach through to the "face" or dial of the clock and carry the "hands." But a clock with weights will not "go" unless it is kept in an upright position; so thinking, ingenious men set to work to invent a pocket time-piece that would keep time in any position. At last they produced the watch, which as you well know, regulates the motion

of its wheels, not by a pendulum, but by the heavy metal wheel called the *balance*.

The process which brings these wonderful little machines out of simple wires of steel, plates of brass, and ingots of gold and silver is very curious.

All the minute parts of a watch are made by machinery in this country. Equally curious with the making of the minute screws is the fashioning of the other tiny parts. One machine punches a plain

round piece of brass; another makes it a skeleton wheel; a third cuts the teeth on a score of wheels; yet another polishes it; then it goes into a room where it is immersed in a solution of gold, thus gilding it; and it comes out one of those beautiful little wheels which you see moving so exactly on its pivot in the completed watch.

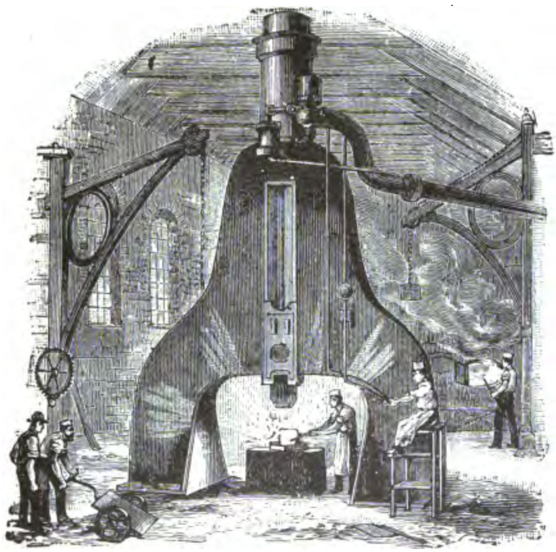
Another apparatus is used to fashion the escapement wheels, with their oddly-turned teeth, and the compensation balance, the most conspicuous of all the wheels of a watch, with its two sections, held together by a thin, diametrical bar of steel, and its outer and inner rims of brass and steel. This compensation balance is one of the most important inventions in the modern watch, as the different degrees of the contraction, or expansion, by cold or heat, of the copper and steel rims, keep the balance constant in all temperatures. No piece, however small, is put into a watch until it has been measured and weighed. There is also a gauging machine for measuring thickness, and still another machine measures the hair springs.

One of the most interesting rooms is that in which the dials, or white faces of the watches, are made. These are at first plain, round copper pieces, cut out of the sheets by machinery. A preparation of white enamel is spread over this copper piece; and when it

is dry it is inserted into a red-hot hole, where the enamel is fused hard on the copper. It is then ground with fine sand and again subjected to fire to give it the glossy appearance which we see on the watch's face.

ENAMELING WATCH FACES.

Another curious room is that where the different brass pieces are gilded by means of batteries and gold solutions. The watches are tested, as to bearing different temperatures, by first being placed in little drawers where the air is made very warm, and then in similar little drawers where it is more than freezing cold.



NASMYTH HAMMER—SLEDGES.

MORE ABOUT IRON.

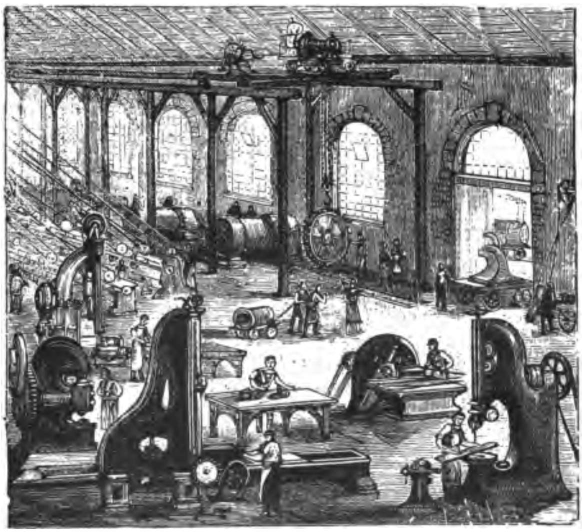
NOW if you are rested by reading about the little ones, we will look at some of the larger of King Iron's children. The armor-plates which clothe our war ships; the eighty or one hundred-ton steel guns with which the vessels are armed; the huge iron beams and girders which span the railway terminus; the iron bridges which cross broad rivers and arms of the sea; the monstrous shafts and

giant fly-wheels which regulate whole systems of mill work, the slabs and masses, rolled, wrought, or twisted — all these are the products of the steam hammer. This monster can strike *his blows with a force to which no limit can be found, yet he can be so perfectly controlled as to crack a nut without injuring the meat.* As the great masses, many tons in weight, move up and down, they look like anvils more than hammers, or rather a dozen anvils welded into one. Down they come with a thud that shakes the ground and scatters thousands of bright sparks. But all steam-hammers are not large; the principle works just as well in a small one.

Tremendous double iron rollers, some twelve feet long, and a yard in girth, relieve the steam-hammer of plate work. Without teeth, they bite the sheet of glowing iron with their gums, and the force of their grip is proved by the effect upon the metal, which goes in thick, and comes out thin, as though it were clay. Backwards and forwards a number of times, and the end is an armor plate, twelve to fifteen inches thick; or a thin sheet, for the tin-plate worker, for the making of pots and pans.

So much do the beauty, strength, and perfect working of a machine depend upon its being exactly right, that the fitting-shop of a machinist, where the bright parts of an engine are burnished and every part is

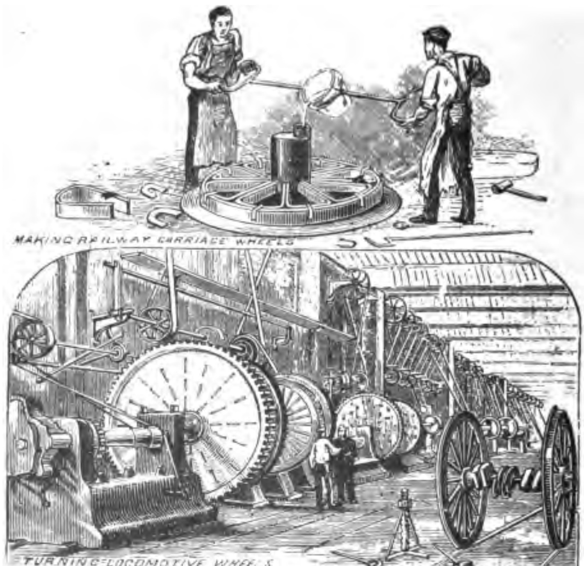
examined and tried, is a picture to dazzle the eye and amaze the senses. One can scarcely believe that the movements of wheels and pulleys, repeated by thousands; with their leather bands depending or stretching from them, over and under, around and about, in and



MACHINE SHOP.

out and everywhere, and making no trifling clash, are merely the tools at work for making engines and frames, and not the finished machinery of a mill. Lathes, planes, and other tools, themselves the product of similar tools, work as if they thought and planned. A ceiling to the room exists only in fancy,

for the roof is but a mass of pulleys; tackle after tackle, the counterparts of each other, and to each tackle a whirring lathe beneath. Each tool has its own duty and goes about it in the din without interfering with its neighbor.



In one place, an immense tube, big enough for a water-main, is peeling itself as it revolves against a sharp tool, and leaves a fanciful heap of iron ribbons or ringlets. Over yonder the tire of a locomotive driving-wheel revolves. Can it be real iron? With each turn, the circumference gets nearer to the centre

by a quarter of an inch. Stop and think what that means. It means that a strip of iron is simply scraped off all around as the wheel turns. Get an iron wheel and a sharp chisel and take off a like circlet a quarter of an inch thick. That will tell you what this lathe does.

Such work as engine and machine-making, where all depends upon the quality of material, must be of forged iron. Even many of the iron wheels of a railway carriage are wrought under the hammer. The spokes are made with club ends, and these when at a white heat are welded to form the box of the wheel. Then again, it is a fiery sight to fit the tires. The red-hot hoop, slung from the forge, hangs evenly over the radiating spokes and drops gently down into its place. Being then deluged with water, it contracts and binds so fast that there is very small chance of its ever after slipping.

SONG OF THE FORGE.

CLANG, clang! the massive anvils ring;
  Clang, clang a hundred hammers swing;
  Like the thunder-rattle of a tropic sky,
  The blows still multiply, —
  Clang, clang!
Say, brothers of the dusky brow,
What are your strong arms forging now?

Clang, clang! — we forge the colter now, —
The colter of the kindly plough.

*   *   *   *   *

Clang, clang! — again, my mates, what glows
Beneath the hammers' potent blows?

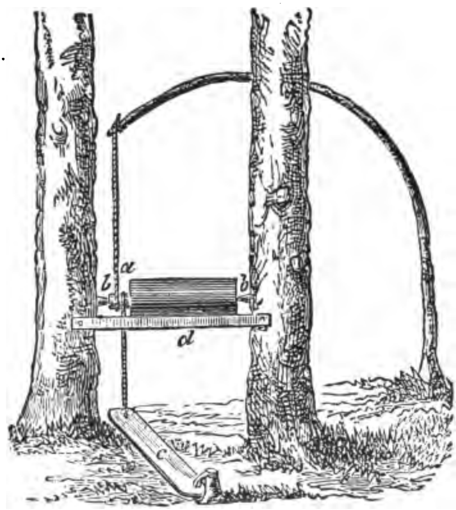
Clank, clank! — we forge the giant chain
Which bears the gallant vessel's strain
Mid stormy winds and adverse tides,
Secured by this, the good ship braves
The rocky roadstead and the waves
Which thunder on her sides.

*   *   *   *   *

Clang, clang! a burning torrent, clear
And brilliant, of bright sparks is poured
Around and up in the dusky air
As our hammers forge the sword.

The Sword! a name of dread; yet when
Upon the freeman's thigh 'tis bound,
While for his altar and his hearth,
While for the land that gave him birth,
The war-drums roll, the trumpets sound,—
How sacred is it then!

Labor is life! 'Tis the still water faileth;
Idleness ever despaireth, bewaileth;
Keep the watch wound, for the dark rust assaileth;
Flowers droop and die in the stillness of noon.



ANCIENT LATHE.

THE LATHE.

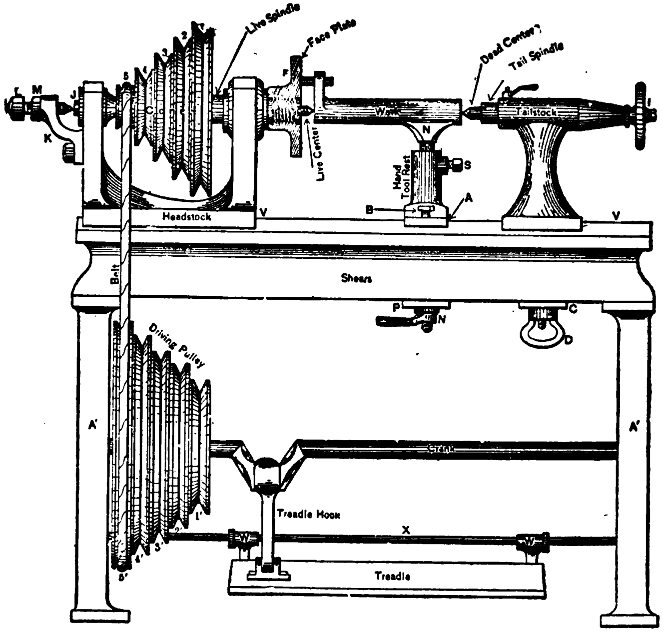
BUT what *is* the *lathe*, do you ask, which seems to play so important a part in so many manufactures?

We do not know when or by whom the lathe was first used, but we do know that an ancient Asiatic nation, living among the Carpathians, used to produce vases with the use of such a lathe as you see in this picture.

The piece of wood to be shaped was held by the pointed plugs of wood (*b. b.*) A cord was tied to a

slender tree, passed around one end of the work, (*a*,) and tied to the treadle (*c*).

Moving the treadle up and down made the piece of wood turn round and round while the workman held a



FOOT LATHE.

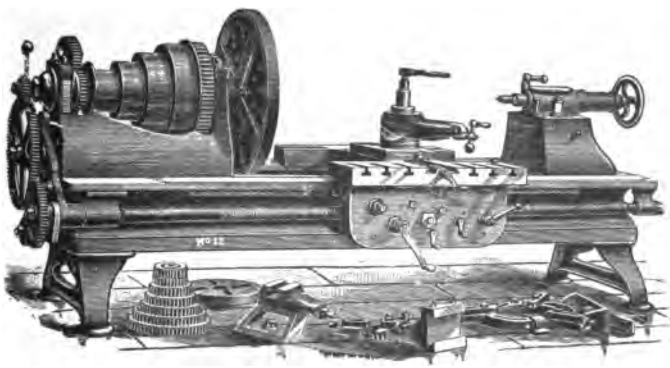
sharp, cutting-tool against it, soon forming it into an even, graceful shape.

Think of a small decimal fraction multiplied and multiplied by itself till it has grown away up among the whole numbers. This ancient, rude affair is the

decimal which ingenuity has multiplied into the powerful machines of to-day.

The simplest lathe used in civilized countries is the foot-lathe.

The treadle, moved by the foot, pulls the driving pulley around. The driving pulley moves the belt; the belt moves the top pulley, which whirls the "live spin-



ENGINE LATHE.

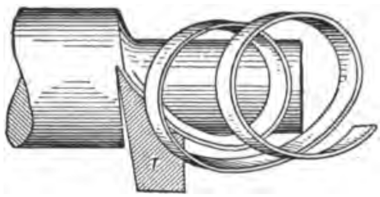
dle" around with it. The spindle, revolving, turns the work around.

To hold the work in place a sort of screw is made, called a "lathe-dog," because it grasps the piece of wood with such a "bite."

The lathe family is very large Some move by hand; some by steam power, and are capable of cutting metal as well as wood. This large one is an "engine lathe" in which the tool moves either along

or across the work by means of self-acting machinery which is all inside and out of sight.

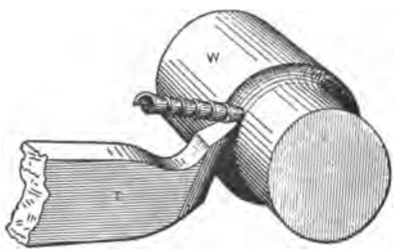
It seems like "witch-work" to watch it moving,



CUTTING WROUGHT-IRON.

cutting off the curled ribbons of iron without seeming to make any effort.

Foremost among lathes is the famous "screw-cutter" which traces a regular spiral upon the work by self-



CUTTING STEEL

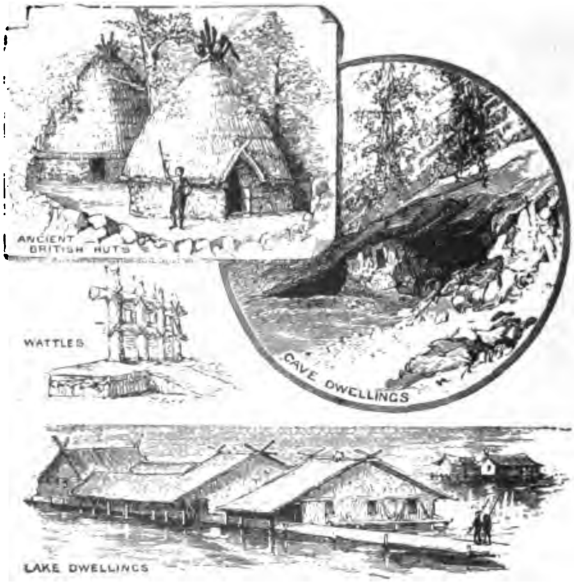
acting means. There is one wood-worker's lathe which we must not forget, because he is such a lively little fellow and makes so many things that we all use: wooden boxes, toy carriages, wheels, wooden balls, etc.

The workman puts a square stick of wood in the lathe and simply pulls the long handle, first in one way, then in another, and so brings four different sets of tools to work one after another. Finally by pressing his knee against a pad which hangs down at the bottom, the finished work is cut off.

You would laugh to see the workman, for he has to use both arms and legs, as well as his knee, at once, and all so rapidly that he looks like a long-legged spider.

Let us be content to work,
To do the thing we can, and not presume
To fret because 'tis little. 'Twill employ
Seven men, they say, to make a perfect pin.
Who makes the head consents to miss the point;
Who makes the point agrees to leave the head;
And if a man should cry, "I want a pin,
And I must make it straightway, head and point,"
His wisdom is not worth the pin he wants.

—MRS. E. B. BROWNING.



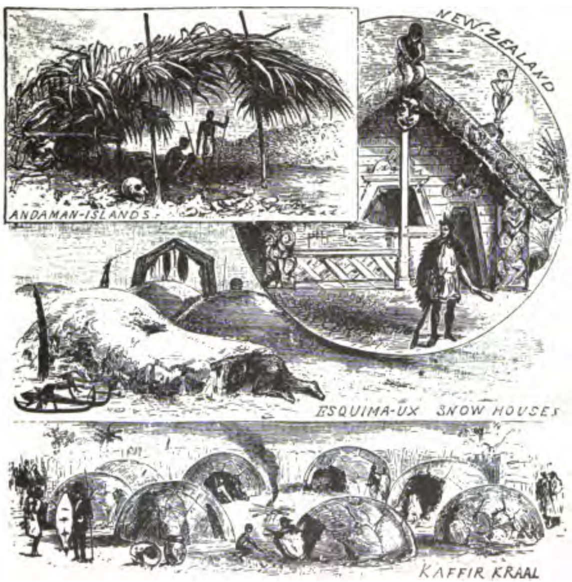
ANCIENT DWELLINGS.

THE STORY OF YOUR HOUSE.

THE Indians of the forest sleep in wigwams; the Arabs of the deserts wander about with their tents; and the tribes round the North Pole build homes of snow. In the days before man had any written history, whole races burrowed under ground, or scooped caves for dwellings in the rocks. In our own country, changes are so frequent, that we cannot be sure of the weather from day to day, and, in certain seasons, hardly from

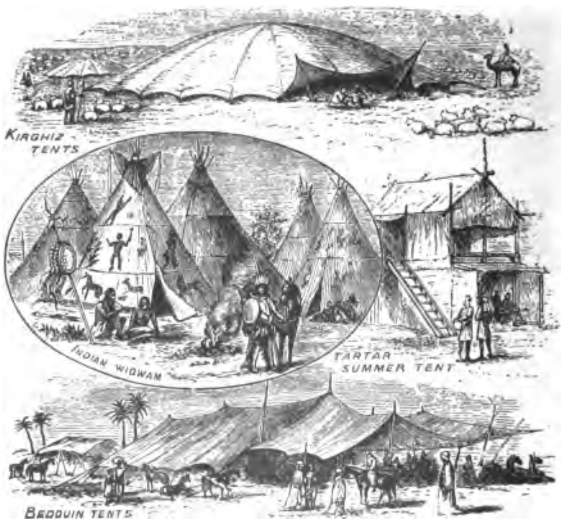
hour to hour. The means of shelter, therefore, has a long history of its own.

The Britons lived in huts, with walls wattled or woven with wicker-work and plastered with mud, till the Romans taught them to make bricks and tiles and



to build strong houses. Roman work was very good and lasting. Though the villas and palaces built by the Romans have long decayed and disappeared, walls still remain as sound as ever round the cities and towns which used to be Roman camps, and still keep their Roman names.

The Normans built great feudal castles, the ruins of which still adorn English landscapes, while their serfs dwelt in mean hovels, with the bare ground for the floor, or, at best, strewn with rushes which were seldom changed. Our own houses are built for health, comfort, and beauty, far beyond the ideas of our fore-



TENT-LIFE.

fathers. Think of the many beautiful public buildings and handsome houses of our own day, and contrast them with what we read of ancient dwellings, and even with what is still the custom in the cold country where the Esquimaux live; where they build houses of snow, and creep into them through small, low openings near the ground.

LUMBERERS AT WORK.

LUMBER.

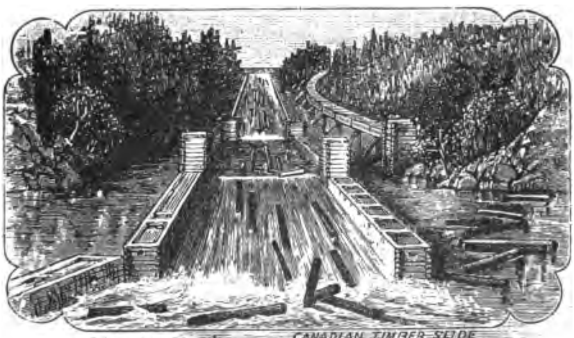
FIRST of all, we will inquire about the timber and boards which form the frame-work of our houses. To have this inquiry answered, you must come, in imagination, with me to some of the lumber regions of our land. Let us go to the lumber regions among the

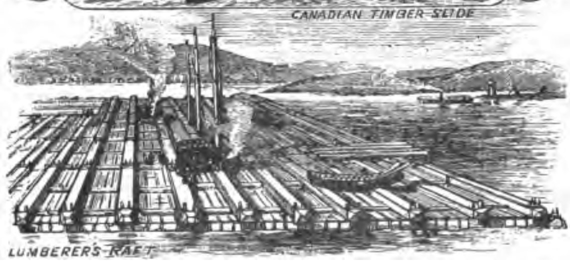
rivers of Northern America. The "master logger" does not lead his sturdy band any further into the forest than is necessary to find good timber, for he is anxious to keep in the neighborhood of some stream. A place selected, the men build rude huts for themselves, during the "logging" season, of mossy logs and stout fragrant branches laid one upon another, much as you build "cob-houses." When these walls are high enough to allow the owner to stand upright, every crevice is stopped with moss. A rude roof of roughly hewn pine boards is put on and a hole is made which serves as a chimney. The cabins are built in so short a time that they look as though they had popped up out of the ground in the night. The beds are armfuls of small fragrant twigs of spruce, fur, or pine.

The whole party is up in the early morning: the cooks fall to work baking bread and slicing salted beef and pork. Breakfast over, the leaders mark the best trees and "logging" begins in earnest. Chopping and sawing go on from morning till night. As the trees fall, one after another, and their branches are cut off, they are hauled together in great brown heaps until sufficient snow has fallen to make the road to the stream hard and even.

The logs are marked, laid on sleds and take their first land journey. The load, arrived at the stream,

now frozen, is toppled over from the sled to the ice. More loads are emptied, and the ice cracks and breaks letting the logs into the water. At last the harvest of timber is piled up for miles along the river not far from the banks.





Here it must rest until the warm spring wind shall come and unfasten its icy chains and set it free. Spring comes at last. The great army of logs has been gathered together and started down stream. It is a long, slow journey. The workers, keeping their slippery positions on the rolling logs, are ready with

sharp-pointed poles in hand to correct any rebellious log that may threaten to block the way.

In the lumber regions of Canada, it is an interesting sight to view the transportation of the timber in the early spring — to hold one's breath as the great mass of logs goes slipping and whirling down the running torrent — down, down, to be caught in the whirling rapids, and tossed and whirled in every direction, until a bend in the river brings them into smooth water again.

Think what a slow, monotonous journey it must be to those men who guide the wide rafts of logs, lashed together, after the rapids and other dangerous waters have been passed, to move slowly along for days and days, within sight and sound of the busy life along the shores. To have steamers, yachts, and even small fishing boats go flying by and leave them far behind.

At last comes one bright day in May when the long journey is ended. The logs are dragged upon the river-bank and taken to the great steam saw mills. Into one side they go and come out at the other cut into boards or timbers of any required size or thickness.

Frameworks of saws, set close for veneers or wide apart for planks, and moved by steam, cut complete logs of timber at one operation: band-saws, or flexible

saws, are made to follow the most delicate tracings of fretwork; and circular saws, from an inch to nine

FELLING AND SAWING.

feet across, revolving at the rate of a thousand turns a minute, cut the largest "baulks" of timber, as if they were but giant bars of soap.

One age moves onward, and the next builds up
Cities and gorgeous palaces, where stood
The rude log huts of those who tamed the wild,
Rearing from out the forests they had felled
The goodly frame-work of a fairer state;
The builder's trowel and the settler's ax
Are seldom wielded by the self same hand;
Ours is the harder task, yet not the less
Shall we receive the blessing for our toil
From the choice spirits of the after-time.

—RUSSELL LOWELL.

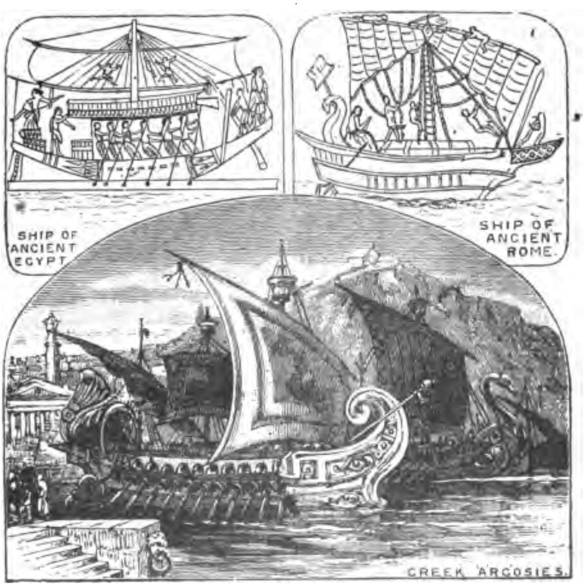
SHIP-BUILDING.

THE largest and finest timbers do not go into house-building, as that ship just coming into the harbor can testify.

How strange the contrast between the civilized man and the savage! By joining together some rough boards, the savage makes a raft, floating at the will of the tide without control. He hews down a tree, scoops out the trunk, and forms a rude canoe. The coracle of the ancient Britons which we

see in the picture, was made by covering a wicker frame with leather or oil-cloth, and it is still used by some of the "fisher-folk" of Wales.

Then there was the ancient galley, or trireme of the Romans, so called because it had three tiers or rows



ANCIENT SHIPS.

of oars; the ship of ancient Egypt and the gaily decorated argosies of the Greeks. The ships used in the fleet of the Spanish Armada were in some respects a good deal like some of our vessels, except that they were fitted with oars as well as sails.

The war galley of the Greeks originally had a single mast and later two masts, but depended chiefly upon its oars, which were ranged in a single line on each side, and each handled by one rower.

Galleys continued in use in the Mediterranean until late in the seventeenth century, and were often from one hundred to two hundred feet long, with twenty oars to each side, and capable of carrying one thousand to twelve hundred men.

Two of the ships in which the discoverers of the New World started on their voyage were of the kind called caravels. They were not decked over, but were built high at either end, with cabins that looked like houses or castles. The bows were broad and they carried four masts and lateen sails.

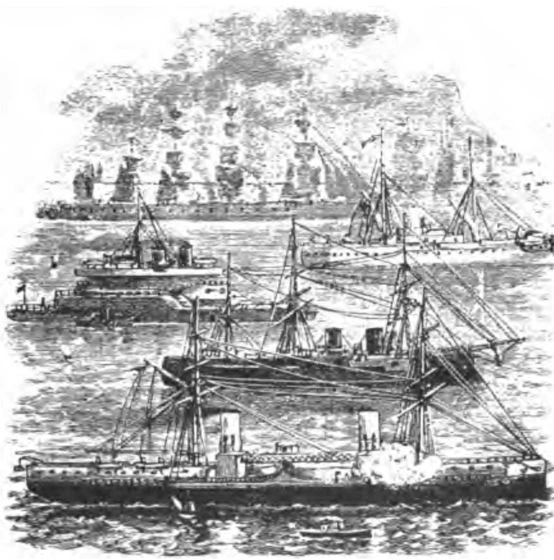
Thus we see the gradual transition from the rude canoe of the savage to the iron clads of war, and the steam vessels of splendid size and comfort which now plough the waves between Europe and America, in as few days as it used to take months.

Ships of to-day are built in different forms according to the burdens they have to carry.

The place in which the ship is built is called a *slip*. In the middle and leading down to the water's edge is a row of piles of stout pieces of wood called *blocks*.

It is a strange sight to see the skeleton of one of these huge ships growing into size and shape; every

piece must be strong and secure. Generally each part must be fashioned from rough logs, but in some "yards" there are machines so contrived as to saw the timbers at once into shapes having the right curves and twist to fit together.

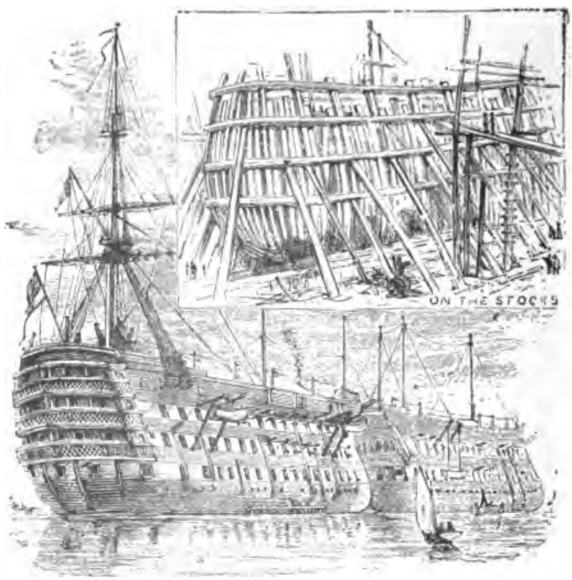


Perhaps you have seen the keel prepared and laid upon the blocks and have noticed how the frame timbers were lifted and fastened to the places they were to occupy.

The shape and means of making vessels may vary a little, but the end and aim of every ship-builder is to

make the whole thing firm, yet light. When the skeleton is at last mounted up in its place it must be clothed or "planked" in as strong and neat a fashion as possible.

This planking is no easy task, for the planks must



SHIP-BUILDING.

be first carefully cut and trimmed, next they have to be steamed to make them manageable, then taken at once to the staging, which has been built round about the great carcass. One end of the hot, sodden plank is fastened and the other coaxed into place. It is held

in its place by various contrivances, till the shipwright has time to fix it securely by bolts of various sorts.

Next follows the ceiling or inside planking of the vessel and the placing of the deck beams, which have to be cut and fixed, so as to bear the great amount of strain put upon them in various ways.

They must fit fast and close to the inside of the timbers, so that they may do their share, aided by pillars, in supporting the heavy loads which the decks have to sustain.

At the end farthest from the water is raised the *stem*, which really is the keel carried upward.

On each side of the upper part of the stem is fixed an upright timber; these are called the *knight heads* and the bowsprit lies between them. The pillars and beams are sometimes made of iron and the decks often plated.

The making of port holes, magazines, bunkers, cabins, berths, etc., goes on by degrees during the building of the ship.

The masts are made by a distinct set of men. There are three masts for a large ship, two for a schooner, or brig, and one for a sloop or cutter. To help make the masts staple, and to fasten the rigging and sails to them there are yards, booms, tops, cross-trees, trestle-trees and timbers, and spars of various kinds.

A very large mast is built up of pieces called spindles, side trees and other odd names, bound together by iron wedges, driven in hot.

To prevent sea-weed and shell-fish from collecting on the bottom, ships are often sheathed with thin sheets of copper, which sheds them off.

THE BUILDING OF THE SHIP.

Build me straight, O worthy master,
Stanch and strong a goodly vessel,
That shall laugh at all disaster,
And with wave and whirlwind wrestle.

* * * * * * * *

There's not a ship that sails the ocean,
But every climate, every soil,
Must bring its tribute great or small
And help to build the wooden wall.

* * * * * * * *

And soon throughout the ship yard's bounds
Were heard the intermingled sounds
Of axes and of mallets plied
With vigorous arms on every side;

Plied so deftly and so well
That ere the shadows of evening fell
The keel of oak for a noble ship,
Scarfed and bolted, straight and strong

Was lying ready and stretched along
The blocks well placed upon the slip.

* * * * * * * *

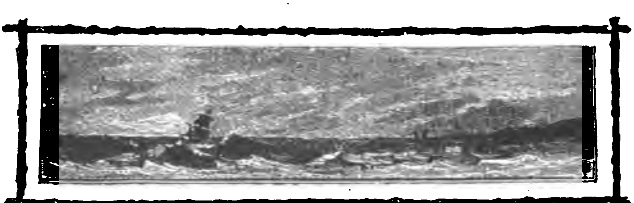
To-day the vessel shall be launched!
With fleecy clouds the sky is blanched,
    And o'er the bay,
Slowly in all his splendors light,
The great sun rises to behold the sight.

* * * * * * * *

Loud and sudden there was heard,
All around them and below,
The sound of hammers, blow on blow,
Knocking away the shores and spurs.

And see! she stirs!
She starts,—she moves—she seems to feel
A thrill of life along her keel,
And spurning with her foot the ground,
With one exultant, joyous bound
She leaps into the ocean's arms!

—LONGFELLOW.



QUARRY.

MARBLE AND GRANITE.

NOW, having seen to what uses the boards and timber are put, let us find out about the stone of which our houses and public buildings are made. Marble and granite are the most beautiful and enduring of all stone, and are the most in demand for prominent buildings and statuary.

Sixty years ago, the land where the West Rutland, (Vt.) marble quarries now are, was a barren looking pasture, overgrown with cedars. Here and there

among the dark evergreens, gleaming white stones showed themselves above the surface of the ground.

Flocks of sheep gamboled, fed upon the scanty grass, or rested in the shadows there, and nobody knew or even dreamed of the immense wealth which Old Father Time, with rain, and sun, and frost for his tools, had hidden away in the rugged hills.

But a Mr. Barnes who had noticed the marble rocks and burned some of them to make lime, believed they were good enough to make tomb-stones.

Everybody laughed at the idea, and so cheaply was the land valued that he bought the whole westward slope of the pasture, giving for pay a poor old horse worth about *seventy-five dollars.*

From this small beginning grew the great marble works of West Rutland. In ten years after the purchase of this land, three quarries were being worked in it.

But all difficulties were not yet overcome. People said that American marble would not keep its purity of color like the imported marbles, so they would not buy them.

But time has proved that the Rutland marble is even better than that of foreign quarries.

Now a line of railroads runs near the quarries, and in the great mills forty-eight gangs of saws, with from eight to forty-eight saws in each gang, run night and

day the year round. Beside this there are ten thousand tons or so of marble shipped every year from this to other mills.

In the hillsides are great pits being dug deeper and wider every year, where men and engines work away in all weathers and seasons.

So deep are the pits that the men at the bottom look like so many toiling ants, and up from the depths, made smoky by the breaths of numerous engines, comes the confused sounds of puffing machinery, clinking drills and murmuring voices. All along the edge of the pits are rows of derricks, stretching giant arms and webs of iron guys against the sky.

The blocks of marble have holes drilled in them about six inches apart; into these holes iron wedges are driven, which split off the rock and lift it a little, ready to be seized and hoisted by the derrick.

The old method of blasting had to be given up because it spoiled many and many a ton of beautiful marble.

In all large quarries the drilling is done by machines which are moved by steam, and which bite at the rock savagely.

About the mills and quarries are old-fashioned ox-teams hauling away cart-loads of waste and rubbish, or dragging great blocks of rough marble to the mills.

Passing near the shouting ox-driver, an engine

draws its cars up among the great piles of unhewn marble.

I have told you of the busy saws in the mill.—"Saws!" do you ask? "Can they saw marble?"

A MARBLE QUARRY.

Yes, not with jagged, slender saws, but with great smooth-edged strips of soft iron, worked up and down by a mighty steam engine of three hundred horse power.

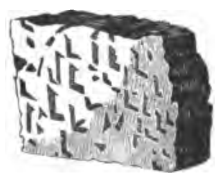
On the top of the block to be sawed is piled a heap of sand which is washed into the cuts made by the saw

by the drip of water from overhead, and answers for teeth to the saws.

The sawing-mill is not a bit cheerful, for it is long, low, dark and damp. The machinery growls and hisses as it gnaws away upon the stone, as if it were some terrible beast dining in his den.

Here in Rutland, marble is as common as bricks elsewhere. All around the mills are rubbish heaps of it: side-walks and floors are flagged and tiled with it.

American quarries furnish as much thin marble for



GRAPHIC GRANITE.

furniture and mantels as do any foreign quarries; for cemetery work and for building we supply an immense amount.

Granite is obtained in much the same way as marble, by drilling and then sawing the blocks; if required smooth, they are ground down with wet sand and emery, and finally polished.

Granite is found in many of the States of the Union. All the New England States produce it and one of them has long been known as the "Granite State."

Can you tell me which one? The famous Quincy granite possesses some of the qualities of the red "Scotch granite."

Granite is used for steps and sills of houses, and frequently for the entire outside of buildings — custom houses and post-offices of Boston and New York, Treasury Building at Washington, which has columns each of a single stone thirty-one feet high; supports of bridges and monuments — Brooklyn Bridge, Bunker Hill Monument, Egyptian Obelisk in Central Park, N. Y.; occasionally for statuary (statue of Alexander Hamilton on Commonwealth Avenue, Boston, the statue of Colonel Cass, and the group on the Ether Monument in the Public Garden of the same city,) though where elaborate carving is required it is not much employed. The statue of Hamilton mentioned is said to be the first ever made of granite in this country, and no other American city has three public statues of this material.

Blocks of granite are used in paving the roadway of the principal streets in our large cities and for sidewalk curbings.

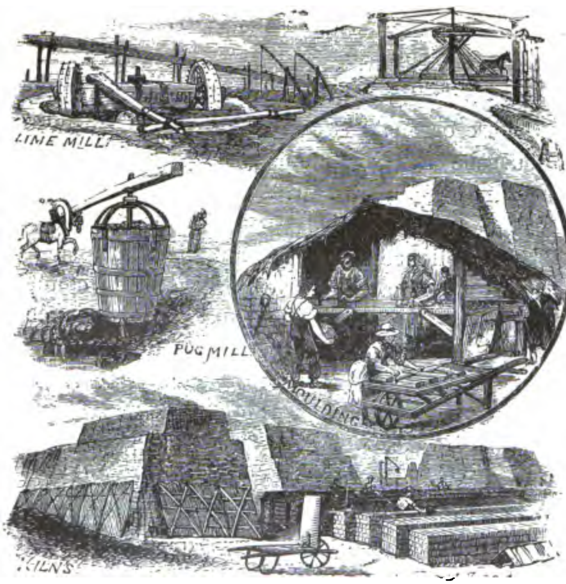
SLATE QUARRY.

SLATE AND BRICK.

HERE is another useful article which is needed in our house building.

Slate is a rock composed of certain parts of clay, which makes it easy to be split into thin plates, and is used for roofing houses; also, tables are made from it, and chimney-pieces, and you are all familiar with the form in which it comes to you for writing upon.

The color of the stone is mostly bluish or blackish-gray. North Wales is the most important slate-producing country in the world. From Pennsylvania, and Vermont comes most of our supply for this country.



BRICK-MAKING.

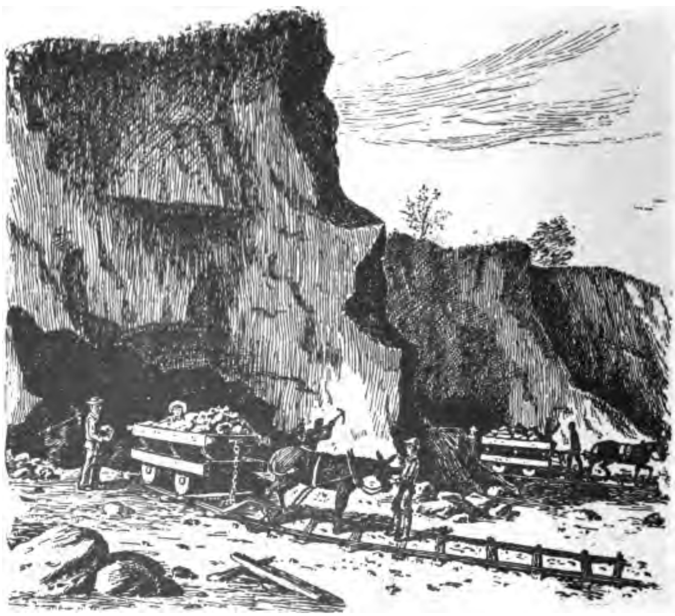
We must not forget to find out about the brick of which we see so much in building houses.

A good authority says," perhaps there is no process so easy to describe and yet so hard to execute as the making of brick ;" and we may well believe it.

Each little detail of digging, kneading, molding

and burning the clay seems to be so simple that it would appear that almost anyone could make a good brick if he only had the necessary materials.

But indeed a great deal of experience and much skill is needed to produce a first quality brick.

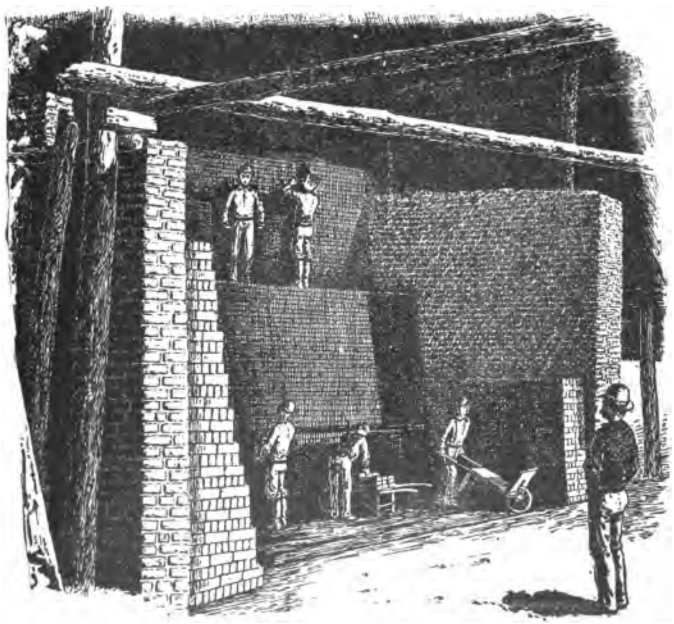


CLAY BEDS.

First of all, the clay is brought to the tempering pit, which is a circular hole sunk three or four feet below the surface of the ground, and from twenty to thirty feet in diameter. In the center is a column, on the top of which is a long horizontal arm carrying

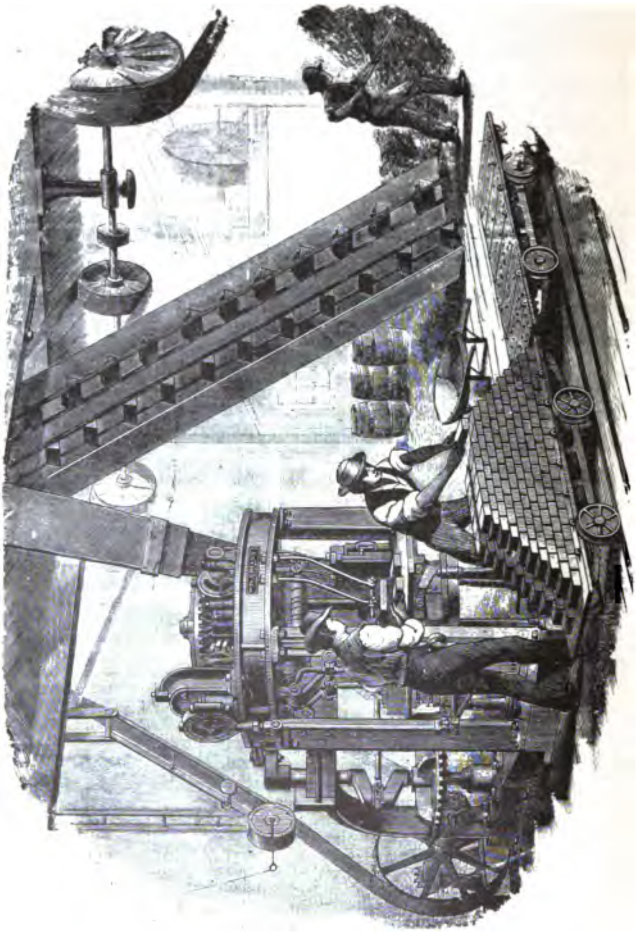
the wheel. This arm is turned round either by horses traveling around the edge of the pit, or by steam.

This wheel revolving thoroughly mixes the clay, so that the ingredients in it are properly distributed, water being added at the same time to give it the right consistence.



FILLING A KILN.

Then the clay is passed to the grinder, placed just at the edge of the yard, a machine which kneads and presses the clay until it is one uniform mass, and is ready for molding.



BRICK-MAKING BY MACHINERY.

The mold, which is a frame having spaces the size of the brick, is first sanded and then placed on a platform underneath an opening in the grinder through which the clay is forced into the molds.

Then after being left to dry, the bricks pass to the kiln, in which they are placed on edge, and between every two bricks a small space is left for the passage of the heat. The fire is started slowly at first, and gradually allowed to increase in intensity of heat, and continued as long as the experience of the burner dictates.

There is a great difference in the nature and quality of the clay found in various localities. It contains much mineral matter, chiefly sand, iron, lime, magnesia and potash.

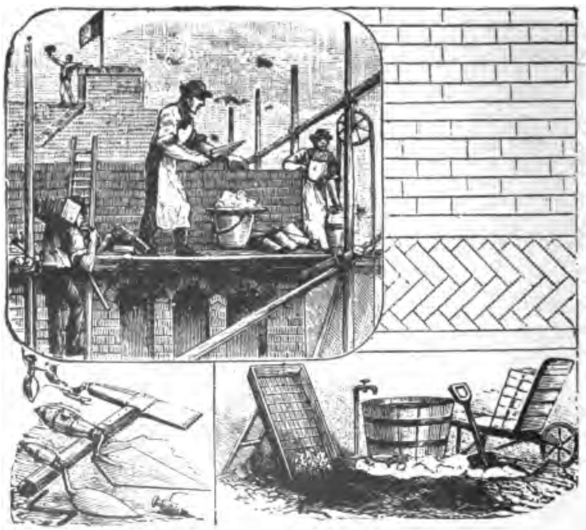
It is the iron which makes the reddish color, and bricks range in color from yellowish cream to dark red.

Blue bricks are made from the same clay as the red, by some peculiar process of controlling the supply of air in burning, and by carrying the heat slightly further.

Of late years the use of machinery in brick-making has been attempted with more or less success, and the future promises that in this industry, as in all others where the demand is great and rapidly growing, machinery will replace hand labor.

Bricks in the United States and Europe are gener-

ally red, but some clays produce yellow bricks, as, for example, the *Milwaukee brick*, which is so much used as an ornamental building material. Bricks in China and Japan are of a slaty-blue color.



BRICK-LAYERS AT WORK.

Philadelphia pressed bricks are in great demand for outer or front walls on account of their perfection. At Haverstraw and other places on the Hudson river immense quantities of brick are made, and the quality of that produced in New Jersey, Chicago, Peoria and other places is considered excellent. Bricks are found to stand fire better than stone.

A VISIT TO THE GLASS WORKS.

WE all want to know how the glass which forms such a useful and necessary article in our houses, is manufactured, and indeed the process is well worth our attention.

It is very interesting and instructive to watch the making of different articles with which we are familiar, so let us pay a visit to a glass works and spend an hour in seeing them manufacture some of those pretty

objects we admire so much, as well as the panes of glass which are put into windows.

We had better begin at the beginning, so let us go into this out-of-door shed, where are such a number of large barrels.

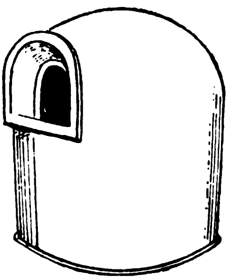
What is this man doing? Mixing what seems like a big pudding in a trough. The principal ingredients of glass are this fine white sand, potash, saltpetre and red lead. They are put together in a crucible — which is a sort of a great jar, with the mouth at the side in-

stead of the top — and placed in a furnace. What a rush of hot air meets us as the man opens a door which leads to these furnaces! Before us towers a dark cone-shaped erection, with openings all round, through which can be seen the intense glow of the molten glass within. Opposite each of these openings is a crucible, and the spaces between are filled up with fuel. All around are men wielding long rods, with what look like globes of fire on the ends.

See the pretty glass jug! So gracefully shaped,

and, as the children say, "such cunning little curly feet." Would you not like to find out how it was made?

There is one just being begun; we will stand here, and see it through. The man we are watching first thrusts his rod, which, by the way, is hollow, into the mouth of a crucible, turns it about for a moment or two, and then withdraws it, loaded at the end with a ball of metal, as the liquid glass is called.



A Crucible.

Blowing the Bulb.

Every trace of sand, lead, and all other ingredients has disappeared, being completely dissolved by the great heat, and pure, clear glass has taken their place. This ball, red-hot, and about as thick as treacle, is rolled for a short time upon a steel plate; then the man blows into it, down the long tube, and we see it swell. He rolls again, and blows again, the globe expanding still more, and now the shaping begins.

This is done with a wooden instrument — from

which the hot glass often causes sparks to fly — the glowing bulb being all the time twirled on the rod to keep it round, else, being soft, it would lose its form. At intervals it is again put into the mouth of the furnace to heat it up, for if it cools too fast, it becomes too hard to manipulate.

Presently he takes up a tool which looks like a large pair of pincers or tongs. With these he makes a hole in the end of the still revolving globe, and, by stretching them open, expands it into a hollow, cup-like form. Then we see the jug is coming.

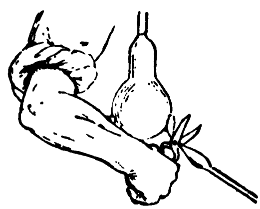
The next step is to mould the neck into shape, for

at first it was upright, rather like a bottle. Then, heating it once more, the man proceeds to trim it around the top with a pair of scissors. Yet so quickly does the "metal" cool, that the pieces, so soft when cut off, fall on the ground with the "clink" of hardened glass, and the jug has to be warmed again before the trimming can be completed and the lip formed.

A FURNACE.

Once more is the now really shapable article held in the fervent glow of the furnace. At this stage of the proceedings a lad comes forward with a rod which is not hollow, and pushing it into another opening of the crucible, brings it out with a small lump of glass on the end. With this he hurries to the first workman, and lets it drop itself upon a certain spot near the bottom of the hot jug, which is held in position for

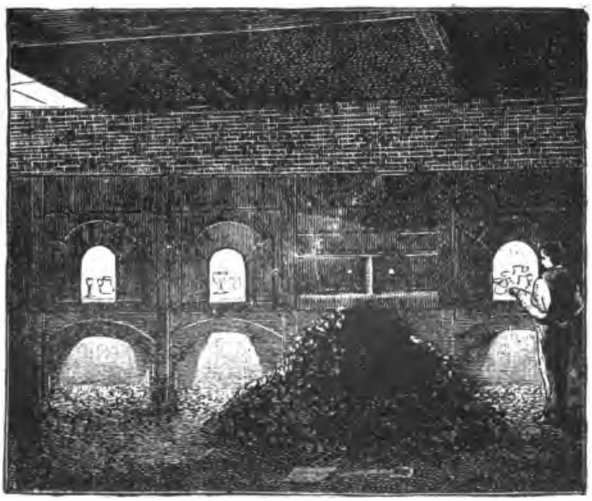
the purpose. These are "the little curly feet." Now the man with the pincers takes hold of the pliable foot, which he has cut off to the length required, and curls it neatly under, exactly like the feet of the jug we admired so much. Then another bit of metal is dropped on just above the first. What is this for? Don't you remember there is a little lion's head at the top of each foot? This is what this last lump of metal is for. The workman stamps the finishing ornament with a stamp or die, just as if it were sealing-wax, and



repeats the process with each of the four feet. Then comes the handle, which is drawn out, of course, while in an almost liquid state, and attached in a similar manner. Now we wonder how he will ever get it off the end of the rod without breaking. The lad comes forward, gives the jug a slight tap, and it is instantly and safely detached. A rough spot, however, remains at the bottom, which will, by-and-by, be ground down on a sanded wheel.

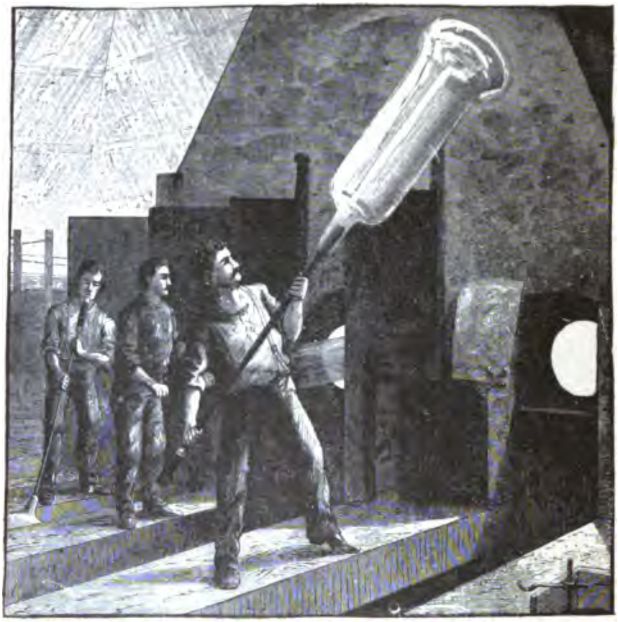
It would be nice to have one of those jugs to carry

away with us, but we should probably break it on the way home, for they are not yet *annealed*, and are extremely brittle. They will have to go into a great oven, which is intensely hot at first, and is allowed to gradually grow cooler. The jugs will not be taken



ANNEALING OVEN.

out till it is quite cold. This process, which toughens the glass and makes it durable, occupies from twenty-four hours to a week, and even longer, according to the size and weight of the articles. Last of all, those pretty little stars will be engraved upon it with a small steel wheel. Then, and not till then, is the glass jug complete.



WINDOW GLASS.

Now let us watch them making the glass which goes into windows. The melted glass having been brought, as we have seen, from a liquid state to the condition in which it may be worked, the gatherer dips the end of his hollow iron rod into the crucible, and collects upon the end a pear-shaped lump of glass. Resting his rod upon a stand, he turns it gently round, and allows the surface of the lump to cool, to fit it for a second gathering. When he has enough he rolls the glass until it is round and tapering to a point.

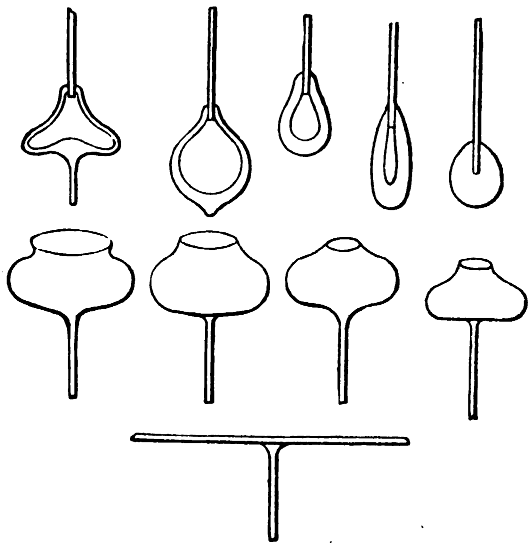
He now blows down the rod, keeping it turning at the same time, and expands the glass into a small

FLATTENING THE GLASS.

globe. Again it is heated, and again blown into a still larger globe. On the next page we see the different stages of blowing and heating from a solid mass to a flattened plate of glass.

All this work must be done with great care, for badly prepared window-glass will lose its transparency on being exposed to

the air, therefore the ingredients for making it must be thoroughly tested before being used.



GLASS TUBES AND CANES.

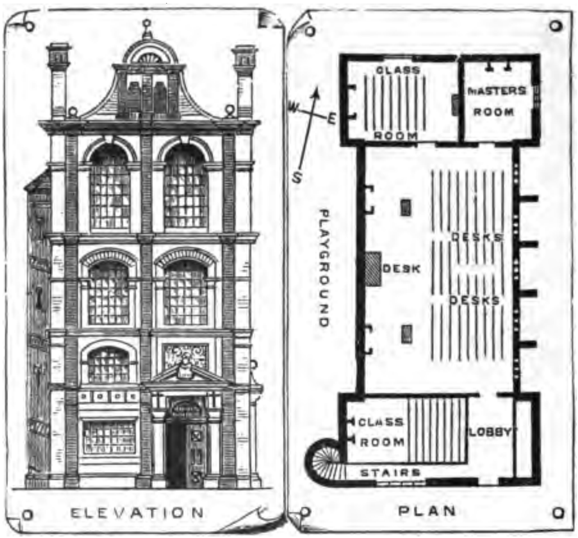
In making glass canes, a mass of glass is gathered and rolled. A flat plate of glass, adhering to a working-rod, is fixed to the end of the mass opposite to where the blow-pipe is attached.

The workman keeps his blow-pipe in his hands, while his assistant holds the working-rod. They now separate, and recede from each other; the greater the distance between them, the greater the length of the

glass will be, and the smaller in diameter. Tube is made in the same way as solid cane, with the difference that the mass of glass is blown into and expanded, before it is drawn out. Tube or cane is speedily rendered workable by the intense heat of the flame, and can be easily manipulated. The lamp-worker prepares from tube some of the most delicate apparatus used in scientific research, also a variety of goods for domestic and medical purposes. Cane is used in conjunction with tube for ornamental objects.

The first glass factory permanently established in the United States was in Brooklyn, N. Y., about 1754, and the first bottle made at this factory is still preserved among the curiosities of the Long Island Historical Society. Window glass was first manufactured at Pittsburg about 1795, and from this time the manufacture of glass steadily increased with the growth of the country, until in 1870 glass factories of every kind numbered about 200.

Since that time the business has developed rapidly, and now the value of the glass produced in this country is estimated at $25,000,000, while the factories number about 400.

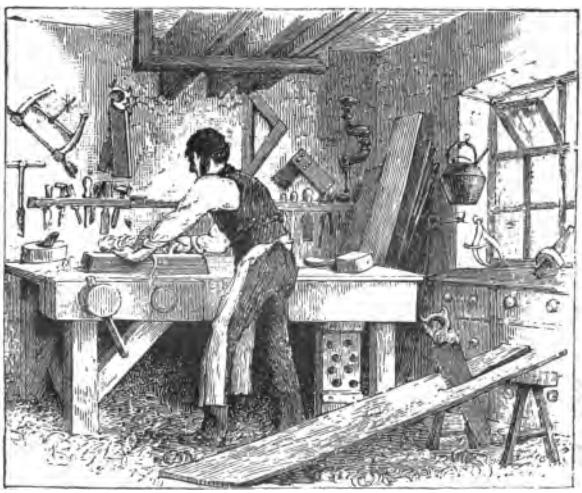


HOUSE BUILDING.

NOW, having got together our timber, stone and glass, we will proceed to build our house.

First of all, the architect gets his plan ready. Here we have a plan showing how a school is to be laid out; where the class-rooms, lobby and stairs are to go. Then there is the elevation of the school-house, showing how it looks when completed. It is the same, of course, with your dwelling-house. The architect had to draw his plan first, then after the bricks or stones were laid for the

foundation, the carpenters came and made the frame, or skeleton, from some of the stronger timbers. Then, for days, the carpenters kept up a banging of boards and a tapping of hammers. Then came the men who nailed with such astonishing speed the grinning rows of laths upon the inside walls. It was the joiner who



CARPENTER'S SHOP.

fitted so neatly together the mouldings and window casings.

A carpenter's tool-chest contains many tools, the purpose, shape and making of which, have been the reward of long thought, and of many minds. It is the great aim of the good apprentice to buy a chest of tools to call his own, and it is his pride, when he

becomes a carpenter, to keep them bright and sharp and in the best condition for use.

A carpenter has rules, axes, and adze, the saw, mallet, hammers, chisels, gouges, augers, planes, pin-

BUILDING PROCESSES.

cers, wrenches, a square, a bevel, a pair of compasses, a gauge, a level and a plumb-rule.

But who is this fellow in his suit of white in the cellar, stirring vigorously with a hoe a mixture of lime, sand and cow's hair? It is the mason. See him now dexterously slapping it on to the naked laths, smoothing and polishing it with a grand flourish, call-

ing out " Mortar ! " now and then to the strong-limbed man who brings up for him hods full of the " plaster."

Then we have the roofer, who puts on the slates and makes the roof sound and tight, so that no rain or cold may get in ; the glazier, who fits in the neat panes of glass for the windows ; and the plumber and

gas-fitter, who lay the pipes for water and gas along the floors and walls. Then come the painters and paper-hangers, who cover the plain boards and plastered walls with pretty designs in painting and wall-paper, and as soon as their work is dry, you may " move in."

POTTERY.

POTTERY.

OTHER necessary articles in furnishing our house are the cups and plates and dishes which we need for our use, besides vases and ornaments which are so pretty to look at and for holding flowers, etc.

These are all made in a pottery, which it will be necessary for us to visit, in order to gain some idea of the way in which these articles are made.

Entering one of the wide, low doors of the pottery we are shown into a room, clay bespattered enough.

In the centre of the floor, clay and water are being mixed into a soft, sticky mass. This is done by a machine turned by horses.

The clay is carried to the next room where the "potter's wheel" is whirling noiselessly. This wheel is a round block about the size of a large dinner plate and fitted horizontally upon a bench.

On the bench beside the potter, the clay is piled, all ready to be shaped. He takes up as much as he can easily hold in both hands, kneads it, and, patting it till it looks like a "mud pie," slaps it down upon the wheel.

He places his foot upon a treadle under the bench, moves it to and fro and the wheel spins round and round with its burden of clay. He takes a flat instrument which looks like a wide knife-blade and holds it against the whirling "pie" till the edge is nicely trimmed. Then, just as though it were some treasure he is trying to hide from prying eyes, he curves his two hands around the wet lump of clay so that none of it except a bit at the centre can be seen. His hands are held perfectly still, but the wheel whirls busily, and lo! the "pie" has changed into a cone-like shape, and looks something like an oversized chocolate drop.

He flattens this at the top with the blade-like tool, pares the sides a little, and, in a twinkling, the whole is changed into the form of a flower pot, bottom side upward.

Now he holds his hands—edgewise, this time—against the revolving clay till it is divided into two sections, held together, and looks a little like an hour glass without the frame, only that the upper section is much the larger.

Now he doubles his fist and plunges it dexterously into the upper section and holds it there, while the clay whirls till a hollow is formed. Now he holds his hands with the thumbs inside the hollow and the fingers outside, takes them off, holds the flat instrument against the edge to flatten it, and against the sides to give them the right curve, and lo! the top section is changed into one of those wide-mouthed, shallow, hanging-pots so pretty for iris or oxalis plants. A few turns more and he has shaped the saucer.

Now he holds his left thumb and fore-finger under the pot, turns the wheel slowly, and, with his right fore-finger, bends an inch or so of the rim into a pretty curve.

One, two, three, perhaps a dozen times he does this until the edge is fluted or scalloped all the way around.

The pot is formed perfectly, but there it is stuck fast to the wheel. The workman holds a brass wire firmly against the wheel and passes it under the spot cutting it free in a twinkling.

Now he lifts it tenderly with both hands and places it upon a board beside him with others. Outside in

the sun and in the long, low, hot rooms yonder are rows and rows of these and other dishes of all sorts of patterns, placed to dry.

When they are thoroughly dried, which will take a number of days, a liquid made of melted sand, lead,

POTTERS.

flour and some other things will be poured over and into them to "glaze" them, that is, make their surfaces smooth and shiny.

We pass along to the kiln. It is built of bricks and looks like a monstrous oven without a door. Into

this the putty-colored pots will be placed carefully, the aperture in the front here will be bricked up; a great fire will be built in each of those oven-like openings in the bricks under the kiln, and the clay pots roasted and roasted in there, in the darkness, till they grow hard and dense; and so red in the face their color will never rub off nor change.

Pottery-making, so the proprietor tells us, while he shows us over the ware-rooms, where the long shelves are piled with all manner of useful and beautiful "crockery," is one of the oldest of the world's industries. The people in the earliest days of Egypt, Babylonia and Assyria sat at the "potter's wheel" and rolled, and dabbed, and shaped the yielding clay much as we have seen it worked to-day.

Dr. Livingstone, traveling in Africa, found that pottery-making had been known to the African people from the remotest days; for broken bits of crockery were found hidden away among the oldest fossil bones discovered in their country.

The most important manufactories of the United States are in New Jersey, New York, Ohio, and Illinois.

But we must hurry away from our talkative friend to another department, where our dishes for the table are made. Though we may all know that dishes in general are made from clay, we perhaps have to learn

now that clay varies in kind, and is mixed with other things in different proportions.

Dried bones, feldspar, broken bits of crockery and more especially hard flints seem odd things enough to mix into a paste, yet here we shall see it done.

The flints are thoroughly baked and burned in a kiln until they have lost their stony hardness and can be ground into powder. While the grinding is carried on, water is poured upon them until the whole forms a fine powdery paste.

We step back a little while the different portions of clay, stone, etc., are being emptied into the "blending-vat." The great wooden limbs of the machine creak and begin to turn at a great rate, setting the liquid all astir. How the mass mingles and foams! We pass on from this vat to another which has finished its work. Here we see the same kind of mixture running out into a cistern through soft, fine sieves.

The clay, ready for working at last, is taken to a "potter's wheel" like the one we saw turning flower pots. In the same way as his pot grew from the coarser clay so from these slabs grow cups, basins, vases; so fast we hold our breath with wonder. This process is called "throwing."

Another thrower is making pretty-shaped, delicate teacups, on just the same kind of a lathe, only he has a mould fixed on the revolving wheel. The cups are

shaped, sliced off and placed in rows on a board so fast that before we can count a hundred, the board is full; is lifted upon a boy's head and borne away to the "hot rooms" to dry. When the cups are hardened a little they will receive a few finishing touches from the "turner."

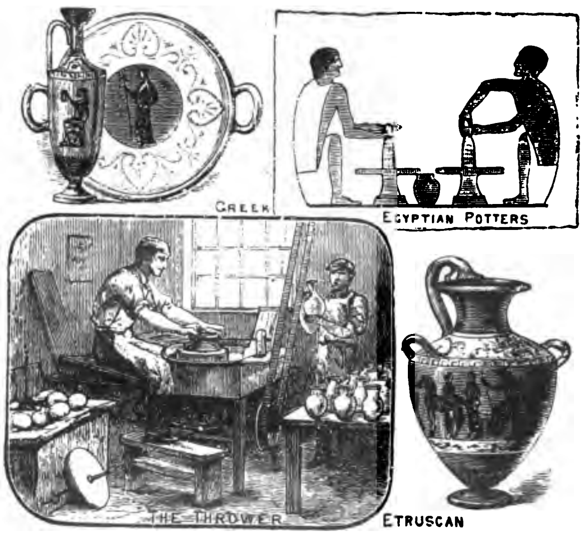
There is another boy carrying out mugs. The shapes look natural, but not the color, for that is like very dirty putty.

A young man is making handles for the mugs. He has two, large, tin trays before him; he takes up, one by one, pieces of wet dough, about four or five inches long, with which a boy keeps him supplied, bends it, and slightly flattens each end over his finger and thumb in a long curve as he puts it down upon one of the trays where he already has long rows of handles. After these are dried they will be fitted on with the "slip" which serves instead of nails in this establishment.

Ewers, basins, tea-pots, candle-sticks, or other things having odd shapes, require to be moulded, and, to make this possible, they must be moulded in separate parts and joined by the "slip."

Two pieces of wet clay are rolled into a paste, then stamped out into two pancakes of about the required size; if they are a little larger it will not much matter, for the trimmings can be worked up again as easily as bits of pie-crust cut from around the plate.

Each of these pancakes is laid in a plaster-of-Paris mould and carefully pressed into its hollows. Then the edges are trimmed off, and the two halves of the mould are joined so as to form one object. If the object requires a handle, spout or knot, it is carried to another room.



POTTERY.

Here one man is making handles; another by his side is making spouts, moulding them in a thing like an overgrown plaster-of-Paris nose. He lines this nose with clay paste, pares off the waste and pulls it out a spout. This process is called *moulding* the ware.

We next find ourselves watching the "flat ware

pressers." At what a rate they can make dishes, saucers, plates! It is no use trying to count them. Here are more pancakes — piles upon piles of them!

A boy hands one to a "presser," who lays it on his plaster-of-Paris-mould, which looks exactly like a stone plate bottom side upwards, and is fastened on a round block. Instantly it begins to spin furiously round, as does everything in this place. The worker holds a tool against the rim, presses it a little and — whir-r-r! the shapeless, flat cake of clay is changed into a saucer or plate which is instantly lifted off the mould and carried away. It is left in the "hot room" for about two hours, when we are told it must be baked, else it would crumble back to clay again. All white ware must be fired at least twice; once before "glazing" to shrink it, and once after the glazing is put on, to harden the glaze.

Going across the yard to another circular kiln, built of bricks and bound with bands of iron, where our paste-like dishes will be baked, we see great, rough shallow pans made of fire-clay.

In a shed, near by, several men are packing all kinds of dishes into these pans or seggars, as they are called. The filled seggars are packed one upon another with their precious contents into the kiln. When all are safely packed, pile upon pile, the door is bricked up and the dishes baked forty hours, sometimes more;

all this time they are carefully watched over by experienced men.

When the cups, saucers, etc., are gently lifted out of their brown baking-pans, they are not red, as were the earthenware pots after baking, but lighter and more delicate-looking.

They are next carried to the dipping-room, a long, low apartment at the other end of the works. At one end of the dipping-room is a kind of deep trough, in which a man with his arms bared is stirring up a soft mass of glaze or varnish. When a dish is set down by his side he takes up each article, one by one, holding it daintily as though it were hot and passes it rapidly through the syrup-like compound. Then he whirls it rapidly about, so that the sticky glaze shall run evenly over it.

The worker tells us that there are numerous kinds of glazing used; some for the cheapest pots; some for press varnishing; some for finer sorts of porcelain. About this glaze every pottery has a mystery of its own.

But how are the pretty ornaments put upon the plates, saucers, etc.?

Before the dishes are glazed they are taken to a long room, where are a stove, a press and several pans of water.

A man is making proofs of an engraving off a cir-

cular copper plate. He rubs a pasty blue ink over the warm plate, and when it has filled the pattern he scrapes it off again from the surface of the other part, then lays on the metal plate a piece of tissue-like paper, and, by means of a squeeze in the press, produces an oily blue proof or picture which, after undergoing a process of washing and rubbing, leaves a bunch of flowers or a pretty landscape, ornamenting what a short time ago was only a plain white saucer or plate.

Thus we see that by man's intelligence our needs are supplied, and the earth made fitter for the habitation of the human race.

Our skill in weaving, our increase in knowledge, our enterprise in trade, our great works of construction, all come from the knowledge of man's weakness and needs.

In a future book, we shall tell you something of the manufacture of other necessaries of life, such as food and clothing, books and newspapers, and all those things which make life so enjoyable.

Chase, A., & Clow, E.,
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